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THESIS

A TASK ANALYSIS OF UNDERWAY REPLENISHMENT FOR VIRTUAL ENVIRONMENT SHIP-HANDLING SIMULATOR SCENARIO DEVELOPMENT

by

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While developing a Virtual Reality (VR) Ship-handling simulator for the Surface Warfare Officer School (SWOS) in Newport, RI, researchers at the Naval Air Warfare Center Training Systems Division (NAWCTSD) in Orlando, FL discovered a need for a task analysis of a Conning Officer during an Underway Replenishment (UNREP). The purpose of this task analysis was to document the tasks the Conning Officer performs and cues used to accomplish these tasks. The task analysis would ensure that the correct tasks and cues would be modeled in the VR UNREP scenario.

The approach taken was to survey cognitive task analysis models to find a notation that would document the tasks performed by a bridge team during an UNREP. The Goals, Operators, Methods, Selection Rules (GOMS) model was selected. A GOMS-like model was used to represent the sequential aspects of the UNREP task, while a table was developed to capture the parallelism of the tasks. The UNREP task analysis was then reviewed by qualified Surface Warfare Officers to validate its accuracy.

The result of this effort was a validated task analysis model of a Conning Officer during an UNREP. This model was provided to NAWCTSD in support of their future efforts in the development of a VR UNREP Ship-handling simulator scenario.

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A TASK ANALYSIS OF UNDERWAY REPLENISHMENT FOR VIRTUAL ENVIRONMENT SHIP-HANDLING SIMULATOR SCENARIO DEVELOPMENT

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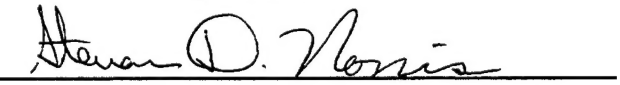
Author: 

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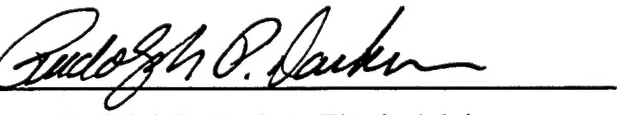
Approved by: 

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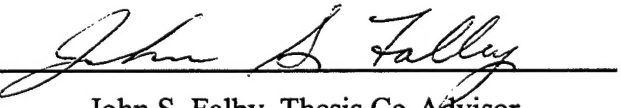

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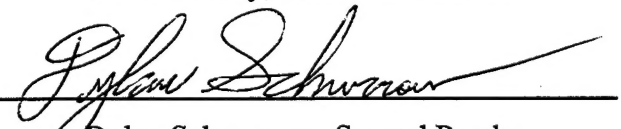

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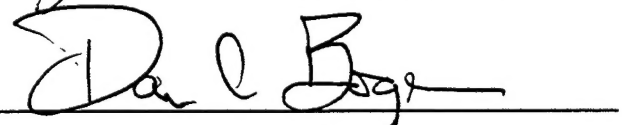

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ABSTRACT

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The approach taken was to survey cognitive task analysis models to find a notation that would document the tasks performed by a bridge team during an UNREP. The Goals, Operators, Methods, Selection Rules (GOMS) model was selected. A GOMS-like model was used to represent the sequential aspects of the UNREP task, while a table was developed to capture the parallelism of the tasks. The UNREP task analysis was then reviewed by qualified Surface Warfare Officers to validate its accuracy.

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I. INTRODUCTION

A. MOTIVATION

Post Gulf War personnel reductions and budgetary cutbacks have forced the United States Navy's Surface Warfare Community to search out new ways to leverage technology against increasing operational commitments and declining assets. As commitments continue to grow and forces shrink, increased demands to produce highly trained officers faster are placed on training programs, and as a result, deficiencies in these programs have become evident. The big question now is how do we meet these training challenges today and beyond [MURP95]?

Historically, Surface Warriors have been slow in demanding the same technology that has been utilized by Naval Aviation for decades. Today, the Navy is placing its money and future in technology. Thus, it appears that advances in training methodologies and technologies offer hope to develop and deliver well trained officers to the fleet in a timely and cost effective manner.

In the last ten years, marine simulators, whether they are for ship-handling, propulsion plant operation, or radar navigation, have caught on in the commercial maritime industry [NIER95]. For the most part, these commercially available simulators have been of the special purpose, room-sized, bridge mockup variety, and are generally manpower intensive to operate. Recently, significant increases in computer hardware performance along with declining prices have made relatively portable, commercial-off-

the-shelf, but highly capable 3D graphics rendering computers, such as Silicon Graphics Incorporated's (SGI) Octane, available for about $20,000. As a result, ship-handling training stands to benefit tremendously by enabling computer-based training system developers to design relatively portable, low cost, network capable VE simulators.

B. OBJECTIVE

A real time, networked, high fidelity, virtual environment (VE) ship-handling simulator that addresses human performance and training requirements would revolutionize the Surface Warfare Officer School's (SWOS) capability to teach ship-handling skills at all levels of officer development, from the Division Officer on up to the Commanding Officer. The specification for this ship-handling simulator is not yet set in stone nor are the requirements well understood. However, the final system should include multiple scenarios, which can be modified to increase the scenario complexity by adding contacts and changing environmental factors, while minimizing scenario redundancy. This simulator will fill two needs for SWOS. It will provided a tool that can be used to teach and reinforce abstract concepts such as relative motion, and it will provide a cost effective method for students to practice many ship-handling scenarios in a safe environment where they can afford to make mistakes and learn from them.

With SWOS's guidance, Naval Air Warfare Center, Training Systems Division (NAWCTSD) researchers are currently in the process of developing a VE underway replenishment (UNREP) scenario to use as a research test bed. This simulation system is currently known as the Conning Officer Virtual Environment (COVE) system. Since

UNREP is a Navy-specific, at sea operation, knowledge elicitation for the UNREP scenario was targeted towards experienced Surface Warfare Officers. After spending several months acquiring the necessary domain knowledge, researchers have developed a high fidelity UNREP scenario that appears to closely model reality. Their goal is to continue to refine the UNREP scenario and to use SWOS students to evaluate its performance. If this evaluation indicates that ship-handling techniques, such an UNREP, can be modeled in a VE with high enough fidelity to make the scenario a beneficial and transferable training experience, the project will be handed off to the next higher level for system development.

At this point in the developmental process, it will be critical that the developers have a superior understanding of the actual scenarios for which they will be writing specifications. Since the developers probably will not be domain area experts, they will need to research each task in depth to develop an understanding of what exactly they are trying to model. The objective of this thesis is to provide a thorough task analysis to support the further development of an UNREP VE ship-handling scenario. A secondary objective is to provide a methodology framework that can be used as a starting point to do task analyses in support of future VE scenario development.

C. APPROACH

This thesis, although related to previous research, is unique because it describes a cognitive task analysis of a shipboard watch team conducting an underway replenishment

task. Previous research has focused primarily on task analysis of an individual performing a task, e.g. a telephone operator interacting with a workstation.

In order to accomplish the task analysis in the most logical and comprehensive framework, while assuring the accuracy as well as validity of the task representation, the analysis and validation were conducted in three phases. First, acknowledging that the teamwork nature of the UNREP task greatly increases the difficulty of capturing the task using a single task analysis method, an analysis method that could be expanded to encompass a complex team executed task had to be found or developed. Second, domain knowledge acquisition was accomplished by using a multimedia UNREP knowledge elicitation tool constructed for this purpose. Additionally, the author has had four years of ship-handling experience as Division Officer in the US Navy. Finally, once the task analysis was constructed, it was presented to several SWOs experienced in UNREP for validation. All data collected during the validation period was scrutinized and corrections and additions were made to the task analysis as necessary.

Subsequent chapters will present each of the above mentioned phases in greater detail.

D. THESIS QUESTIONS

The following questions are addressed in this thesis:

- *What specific tasks are required of a conning officer during an UNREP?*
- *What are the cues used for ship-handling during an UNREP?*

- *What is a suitable level of analysis and associated methodology required to conduct a task analysis of a ship-handling task?*

E. SUMMARY OF CHAPTERS

The remainder of this thesis is broken down into the following chapters:

- Chapter II provides a more detailed discussion of the current training situation at SWOS as well as a proposed solution. Additionally, previous and current VE ship-handling simulation research is discussed. Finally, a brief explanation of ship-handling fundamentals is provided.
- Chapter III discusses a methodology for constructing a cognitive task analysis. This chapter also discusses question set development as well as limitations of the thesis.
- Chapter IV examines the UNREP task and discusses basic ship-handling principles and terminology.
- Chapter V provides the details of the implementation of the task analysis and the data collection process.
- Chapter VI presents a final discussion of the results of this thesis and describes areas requiring further research.

II. BACKGROUND

A. CURRENT SITUATION

The primary force behind the push to build a VE ship-handling trainer for the Navy is the Surface Warfare Officer School (SWOS) in Newport, Rhode Island. SWOS is the center of all Surface Warfare Officer (SWO) training, from the most junior Ensign to the most senior prospective Commanding Officer (CO). However, the current simulator available at SWOS is at best a navigation simulator. It is only used during Division Officer training and is inadequate and unable to meet the training requirements of intermediate to advanced level ship-handlers. As a result, SWOS Department Head students are sent to use a simulator located at the Marine Safety Institute for approximately 16 hours out of the six months spent at Department Head School.

How does a SWO acquire ship-handling skills today? On-the-job training is unfortunately the answer. The following is a brief summary of the training SWOs receive at various stages of their careers. As Ensigns, potential SWOs attend six months of schooling at SWOS Division Officer Course (SWOS DOC) where they receive instruction on a broad range of topics to include: personnel management, damage control, engineering systems, combat systems and ship-handling. Prior to 1993, Yard Patrol (YP) boats were used at SWOS to provide ship-handling training during Division Officer training. However, due to the age of the YPs and lack of funds to replace them, these assets are no longer available at SWOS. YPs are still in service at the Naval Academy

and are utilized to teach Midshipman basic ship-handling skills. After graduating from SWOS DOC, junior officers are assigned to a ship in the fleet where they start an eighteen-month to two-year qualification process. To qualify as an Officer of the Deck (OOD) is one of the first major milestones in an Officer's path to qualifying as a SWO. Generally, an officer will qualify as a SWO soon after completing the OOD qualification. While the actual shipboard qualification process varies from ship to ship and is largely dependent on the ship's CO, qualification typically includes learning the ship's combat and engineering systems as well as spending hundreds of hours conning the ship under the instruction of a qualified SWO. During this qualification process, the officer must complete the required Personnel Qualification Standards (PQS) books in a number of areas to include: bridge watch standing, engineering, combat information center watch officer and damage control. Finally, after completing all the PQS requirements, the officer must pass a rigorous oral board exam with the ship's CO. This qualification system requires having more than the minimum required number of officers onboard so that the qualified officers can train the unqualified officers who will replace them.

Once qualified, SWOs usually are given charge of their own watch section and are permitted/trusted by the CO to drive the ship safely in accordance with the Rules of the Road and the CO's Standing Orders. Standing Orders are a Captain's personal instructions to the OOD on how the ship will be operated at sea. Now fully qualified, these junior officers will log hundreds of hours standing OOD watch over the next couple of years while on various overseas deployments. After serving about two years as a

qualified OOD, or approximately at the four-year point of the SWO career path, Officers have a couple of options: (1) stay at sea for two more years and go to another ship where their ship-handling skills should continue to develop, after which they will usually go on to Department Head School back at SWOS; or (2) take a shore duty assignment for two years where their ship-handling skills will likely deteriorate over time, after which they will also go on to Department Head School at SWOS. Officers who choose the first choice do so for one of the following reasons: (1) they have not qualified as a SWO on time; (2) they have not received great Fitness Reports on sea duty; or (3) some believe that staying at sea is the way to the fast track in the SWO community.

After returning to SWOS for Department Head School, the Officers may either have very sharp ship-handling skills as a result of extended time at sea or their skills may be somewhat rusty from being away from a ship for a couple of years. In either case, both groups must meet the same requirements at Department Head School as well as at sea. There is currently neither a requirement nor a method in place for officers on shore duty to maintain their ship-handling skills. After two years of shore duty, SWOs returning to SWOS for Department Head (DH) School receive a very limited ship-handling refresher. As a result, newly assigned DHs report to their new ships where they are expected to train and qualify junior officers with tarnished, if not rusty, ship-handling skills. Clearly, this is a problem.

Even commercial and international agencies have started to experiment with using ship-handling simulators to train and qualify ship handlers. Recently, some nations, the

United States included, have started to offer commercial mariners who seek a Masters license the choice of either taking the traditional written exam or taking a partial written exam along with a simulator-based bridge performance assessment [NIER95].

B. POSSIBLE SOLUTION

How do we meet these training challenges today as well as in the future? The real answer for the Navy is very complicated and somewhat political in nature. However the development of a relatively low cost, portable VE simulator would be a step in the right direction.

A close look into ship-handling simulators available worldwide reveal that there are generally two types of ship simulators in use or under development; the bridge mockup and the Virtual Environment experienced through a head mounted display (HMD) or desktop monitor.

The bridge mockup is the more expensive option, requiring more people to operate while providing services to only a small group of officers attending a particular school. However, there are a few benefits associated with the bridge mockup interface. For example, if used as a team trainer, it can build teamwork among watch team members. Also, the bridge mockup provides the user with a more realistic user interface since instruments can be almost identical to the actual instrumentation onboard a ship. Users of this type of simulator can touch and manipulate the modeled equipment in the mockup in the same way as they would the actual equipment in reality. For example, the Conning Officer can see an actual RPM indicator or rudder indicator map.

Mockup type simulators are the most widely used in the civilian sector today. More than a dozen marine safety schools around the world offer courses, which include simulator-based training. However, VEs experienced through HMDs appear to be the future of training simulators. This is a less expensive, more portable alternative. Large staffs of instructors/operators are not required to maintain and operate these systems. As for the interface, the immersive qualities of the HMD may allow VE simulators to provide a greater sense of presence within the environment. The drawback is that outside of visual presentation, there are few ways available today to interact with the environment using any of our other natural senses. Haptic feedback devices and speech recognition systems are still largely open research areas which have not produced many commercially viable products as yet [DURL95]. In other words, the technology to make a real world VE simulator that is up to standards depicted in recent movies is not currently available. However, today's VE technology can provide significant improvements over current training simulator alternatives. The question is how much improvement to expect and how to get it.

What should the Navy look for in a VE ship handing simulator? A simulator that will fill the void must be available to Surface Warriors of all levels, stationed throughout the world. This implies that the computer hardware the simulation runs on must be a sea going system or, at a minimum, be available pier side. It must correctly model ship-handling tasks by providing high fidelity environmental and vehicle models. This ship-handling simulator should be designed to be network capable from the beginning. This

would ensure that it could be integrated with other military simulators currently under development. Another benefit of having a networked system is that the actual participants within the VE could rehearse at-sea operations before getting underway to do the real thing. Currently, ships from Mayport, FL and Norfolk, VA get underway, meet someplace in between, rehearse for a day, and then do the exercise. This is not to say that VEs can totally eliminate the need for practice at sea, but they could potentially enable more effective use of time spent underway.

A simulator meeting these requirements would provide the most flexible training aid to naval leaders. COs could schedule their officers for simulator time during extended in-port periods. This would allow junior officers to log simulator time while in port as well as provide COs with a better mechanism to evaluate and/or monitor junior officers progress through a simulator debrief report/evaluation. In the best case, providing officers with the opportunity to do simulated maneuvers while in port could significantly reduce the time required to qualify, thus supplying the fleet with qualified ship-handlers faster. At a minimum, the VE simulator would allow Conning Officers to practice dangerous maneuvers (e.g. Underway Replenishment and Plane Guard) and emergency procedures (e.g. Man Overboard and Engineering Casualties during restricted maneuvering) in a safe environment where they can learn from their mistakes.

C. CURRENT RESEARCH

With a better understanding of the Navy's need for a VE ship-handling simulator, a further discussion of current research is appropriate. This section as well as the

remainder of the thesis will focus on research being conducted in support of developing a VE based system. Three ongoing projects have made significant progress in this area. The first system of interest is the Canadian Navy's MARS project. The second and third projects, the Virtual Environment for Submarine Handling Training (VESUB) and Conning Officer's Virtual Environment (COVE), do not share identical goals, but are co-located at the Naval Air Warfare Center Training Systems Division (NAWCTSD) in Orlando, Florida.

1. MARS Virtual Reality Simulator

Canadian fleet reductions, growing reliance on reservists, and the high costs and difficulties of training officers at sea prompted the development of the MARS VE simulator. In 1991, the Chief of Maritime Doctrine and Operations requested the investigation of VE technologies that would enable the development of a low-cost simulator for training ship-handling skills. Formation maneuvers were identified as a prime requirement of the system [POIN95]. As a result, an exploratory development model was constructed to determine the technical challenges and risks associated with using VE technology to train Officers of the Watch (OOW). The target users of the system were to be junior officers at the Canadian equivalent to SWOS.

The system consists of a network of simulators, each of which can be configured to simulate any ship class in the Canadian inventory. Each simulator is broken into three functional components: the OOW interface, the simulated bridge team, and the instructor control facilities.

The OOW interface uses a commercial HMD and electromagnetic tracking system as depicted in Figure 1. The hydrodynamics and physical appearance of any Canadian ship can be modeled. Bridge instruments are computer generated and displayed in the VE. A speech recognition system and sound generation system are used to recognize verbal commands and play recorded sounds such as engine noise.

Figure 1: MARS Virtual Reality Simulator HMD.

The simulated bridge team uses the sound generation system to play back a unique voice for each bridge team member when interacting with the OOW. The voice recognition system recognizes orders given by the OOW and initiates the required changes to the throttle and rudder. Instructors are also able to interact with the OOW through the sound generation system. This eliminates human to human interaction during the simulation. Additionally, the time stamping and recording of all commands provides a valuable tool for evaluation and debriefing. The instructor control facilities enable lesson

planning, simulation monitoring and control as well as providing for review and debriefing.

Training effectiveness testing has included allowing half of two separate classes to use the VE simulator for a week, while their classmates received the regular program of instruction. Both groups were then required to do formation maneuvers on the equivalent to the previously mentioned YPs. The results showed that the groups who were exposed to the VE simulator performed better at sea. A separate experiment showed that, through the use of several networked simulators, it was feasible for multiple ships to do exercise rehearsals within the VE [POIN95].

2. Virtual Environment for Submarine Handling Training (VESUB)

VESUB came about as the result of a recognized training deficiency. Specifically, submariners did not have a simulator that allowed them to practice entering and/or leaving port. This is a significant problem due to the nature of submarine operations. Typically subs go to sea, submerge for a few months, and then return to port. This operating schedule allows few officers a chance to practice harbor entries and pier work. NAWCTSD researchers built an exploratory simulator system to evaluate the potential of training submarine OODs to drive in a VE. Figures 2 and 3 show the HMD and the VESUB model as seen through an HMD. The VESUB system has been well liked by evaluators and trainees and is currently being upgraded to provide a more robust simulation for further evaluation at Submarine School in Groton, Connecticut [NAVL98].

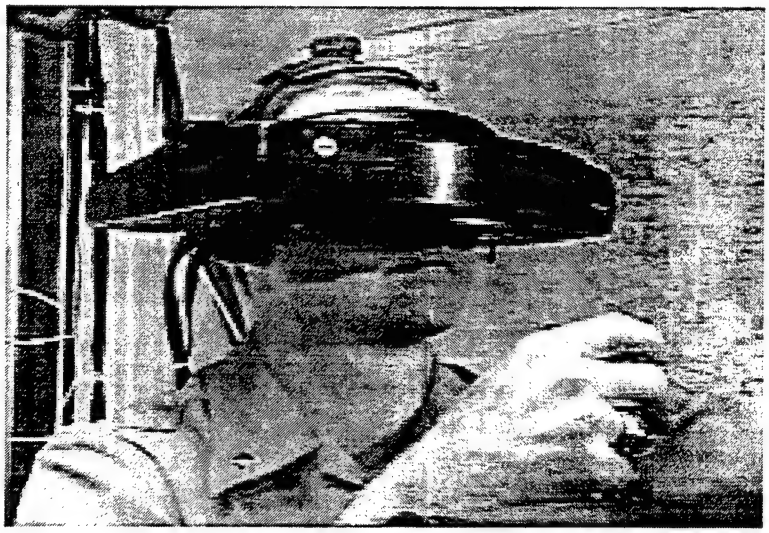


Figure 2: VESUB HMD.

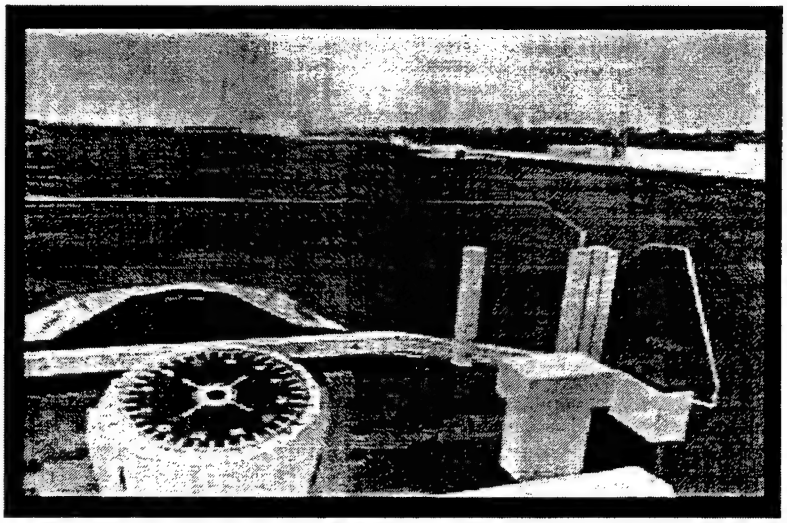


Figure 3: VESUB Bridge View.

3. Conning Officer's Virtual Environment (COVE)

Extensive research regarding the possible benefits of training ship-handling tasks in a VE is being conducted under the Virtual Environment Training Technology (VETT) project sponsored by the Office of Naval Research (ONR). While VETT research covers a wide spectrum of VE topics, this thesis is in support of NAWCTSD's current effort to

develop a VE UNREP training scenario. As previously mentioned, this thesis constructs a cognitive task analysis of an UNREP for future use in the development of the system specification for the actual UNREP scenario delivered to SWOS with the VE ship-handling trainer. A VETT research goal is to determine how well ship-handling skills trained in a VE transfer to real world ship-handling maneuvers. NAWCTSD researchers and contractors are currently in the process of developing a VE UNREP scenario to use as a test-bed. The goal is to use this test-bed to break down primary ship-handling tasks into abstract sub-tasks that can be used to teach ship drivers the underlying fundamentals of ship-handling.

The model is functional but not yet fully developed. It has multiple ship class models and modifiable environmental effects. Figure 4 is a screen capture of the most resent version of the COVE model.

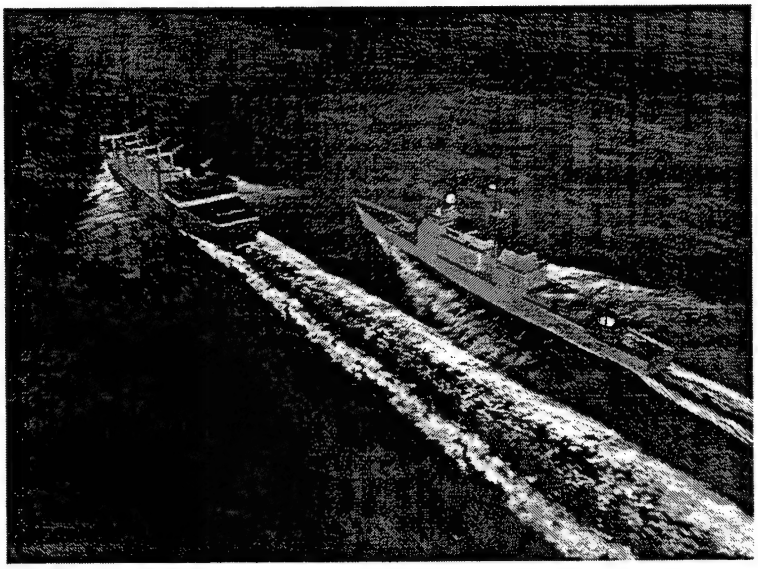


Figure 4: The COVE ship handling model.

The model is experienced through an HMD and electromagnetic tracking system or desktop monitor. Currently, user commands are received verbally by a research assistant and then entered into the system. The user-independent speech recognition software has not performed up to expectations, and is currently a hurdle that must be overcome. The model's visual and hydrodynamic handling fidelity have thus far been well received by SWOS students of all levels. The simulator was unveiled and exposed to SWOS students for the first time in March of 1998. The objective of the trip was to see how SWOS would respond to the simulation and to collect feedback from domain experts.

By all accounts the students at SWOS thought the COVE simulation was very accurate and would be a useful training aid.

III. METHODOLOGY

A. TASK ANALYSIS

The simplest definition of task analysis is the observation of a human performing an activity, usually involving a machine interface, followed by recording detailed information describing the tasks that the person must accomplish to achieve a given goal. However, there is not a universally accepted definition of what constitutes a task, nor is there agreement of what components the task analysis process consists. Additionally, there have been few exact notations or recording systems developed to capture complex tasks in a standard format [CARD83]. Although much progress has been made related to the methods and theories used in cognitive task analysis, it has been strongly associated with the development of cognitive task analysis techniques for individual human performance rather than team performance. However, the complexity of tasks such as ship handling dictates that decision making and task accomplishment be achieved as a team effort. Comparatively little research has thus far been dedicated to the analysis of team decision-making and problem solving. Recent research at CHI systems has attempted to modify the currently accepted COGNET model of individual human task analysis so that it encompasses the team executed task domain [ZACH97]. Although not as advanced as research done at CHI systems, this thesis research lead to a similar solution to the current void of a team task model. The solution developed herein will be

explained later in this chapter, but first the sequential CMN GOMS model will be discussed.

1. Models Used

The GOMS (Goals, Operators, Methods and Selection Rules) family of cognitive task analysis models is a well-established set of models that are frequently used to model human-computer interface tasks. There are several spin-off models, such as CPM (Cognitive, Perceptual and Motor or Critical Path Method) GOMS, from the original notation, known as CMN GOMS, introduced by Card, Moran and Newell in their book, *The Psychology of Human-Computer Interaction* [CARD83]. This thesis limits the discussion of task analysis models to those models that were used or strongly considered for use, namely CMN GOMS and CPM GOMS.

2. Selecting a Model

The primary reason there have been so many models developed, and that there is not a universally accepted model, is because each problem domain often requires a customized model to capture the tasks executed within that domain. For this research, the CMN GOMS model was selected to model the sequential tasks, since it only required slight modifications. CMN GOMS, also known as KLM (Keystroke-Level Model) GOMS, was based on the sequence of keystroke-level actions the user must perform to accomplish a task [KIER94]. It is the easiest and most fundamental level model of cognitive task analysis. CPM GOMS was initially strongly considered to model the

parallel tasks associated with UNREP; however, it was designed to model parallel tasks within a single human not a team. It turned out that CPM GOMS was not used. Rather, a parallel task table was developed to capture the parallelism between the tasks accomplished by each of the bridge team members. A full explanation of the parallel task table follows later in this chapter.

B. CMN GOMS NOTATIONS

CMN GOMS is made up of Goals, Operators, Methods and Selection Rules. Goals define what is to be achieved and present a set of possible methods by which it can be accomplished. There are several levels of goals, the highest being the Unit-Task-Level, next the Functional-Level, and finally the Argument-Level. Within each of these levels there are usually sub-goals and sub-sub-goals that are required to accomplish complex tasks. These sub-goals are in some instances also called Methods. Methods are essentially the procedures used to accomplish a goal. Operators are elementary perceptual, motor, or cognitive acts that are required to change the user's mental state or change the task environment [CARD83]. Selection Rules allow the user to choose the optimal method to use for a particular task when presented with more than one method.

How does one do a CMN GOMS analysis? The first step is to determine the task to be modeled. Next, generate a task description by picking high level goals. Determine the methods that are required to accomplish the high level goals. These methods may invoke sub-goals as they are executed. Determine the methods required to accomplish the

sub-goals that were identified. This process breaks down larger goals into smaller sub-goals that require a very specific method or operator to be accomplished. It also groups goals into Unit-Level, Functional-Level and Detailed-Level. The above process stops when the operators required to achieve the methods are reached.

CMN GOMS notation is very similar to an outline. The higher level goals are left justified and the other goals, operators and methods are indented to the right according to their position in the hierarchy. In order for a Functional-Level goal to be accomplished, all the subordinate sub-goals and methods below it would have to be completed first. For example, in Figure 5, Turn_Ship is the Functional-Level goal, and the goals Visually_Verify_Direction_Of_Turn_Clear, Issue_Rudder_Order, Starboard_Turn, Determine_How_Far_To_Turn and Determine_Degree_Of_Rudder_To_Use must be completed before Turn_Ship is accomplished.

```
. . . goal: Turn_Ship
. . . . goal: Visually_Verify_Direction_Of_Turn_Clear
. . . . . [select: Walk_To_Bridge_Wing_Of_The_Direction_Of_Turn_To_Look
. . . . .          Request_Another_Watch_Team_Member_Visually_Check]
. . . . goal: Issue_Rudder_Order
. . . . . [select goal: Starboard_Turn
. . . . .          . goal: Determine_How_Far_To_Turn
. . . . .          . . [select: Use_Prior_Experience_To_Estimate_Distance
. . . . .          . .          Use_Radian_Rule_To_Monitor_Turn
. . . . .          . .          Follow_CO's_Orders]
. . . . .          . goal: Determine_Degree_Of_Rudder_To_Use
. . . . .          . . [select: Use_The_Rule_Of_Thirty_To_Determine_Amount
. . . . .          . .          Use_Prior_Experience_To_Estimate_Amount
. . . . .          . .          Follow_CO's_Orders]
. . . . .          . goal: Give_Verbal_Order_To_Helm
```

Figure 5: Example CMN GOMS Notation

The granularity of the CMN GOMS model can be adjusted to capture various levels of detail and different parts of the model can be done at different levels of detail [CARD83]. The standard CMN GOMS model required a couple of slight modifications in order to customize the model to efficiently and effectively capture the Execute_UNREP task. UNREPs typically take hours to complete and involve many of the same tasks being repeated over and over in sequence. It was determined that it would be best to document the task or task sequence once and then call the task by name as a sub-routine whenever it reoccurs or loops. These situations are noted in the CMN GOMS-like analysis in chapter five as loops or repeated tasks. An example of a looping task sequence occurs when own ship is maintaining station alongside the replenishment ship. The Conning Officer must repeat the same tasks over and over, for hours, in order to maintain station. Second, some tasks are repeated periodically or whenever the overall task load allows. These are denoted as periodic tasks in chapter five. Goals such a Maintain_Awareness_Of _Third _Party_Ships is a good example of a periodic task. The Conning Officer should scan the horizon for contacts as often as possible.

C. PARALLEL TASKS WITHIN A TEAM

This portion of the thesis sailed into uncharted waters, so to speak. As previously mentioned, little research has focused on formulating a methodology or notation for capturing team accomplished tasks. A goal of this thesis was to capture the parallelism in a task accomplished by the combined actions of each member of the bridge watch team.

After an exhaustive search for an established methodology that would accomplish this goal, which even included considering modifying a parallel programming notation. It was decided that a table constructed of the CMN GOMS-like notation discussed in section B of this chapter would best capture the team, as well as parallel, aspects of the task.

1. CPM GOMS

CPM GOMS was designed to be suitable for analysis of parallel activities [JOHN94]. CPM GOMS is also known as Critical Path Method GOMS because it can be used to construct a cortical path of tasks on a PERT chart type graph. CPM GOMS is intended to analyze at the operator level of individual cognitive, perceptual, and motor operations. For example, when humans see an object move, they first attend to the visual stimuli, a cognitive operator, then they perceive the motion, a perceptual operator, followed by moving their eyes to follow the motion, a motor operator. CPM GOMS results in an extremely detailed level of analysis. CPM GOMS was strongly considered for the parallel portion of the analysis presented in chapter five, however, it was not easily modified to capture a team executed UNREP task.

2. Parallel Task Table

The parallel task table basically takes the CMN GOMS notation for each of the watch team members, Conning Officer, Officer of the Deck, Helmsman and Lee Helmsman, and puts it into a tabular format. The sequential tasks associated with each watch team member are listed vertically in a column next. A very rough time line runs

along the vertical axis of the table. This time line is intended only as an approximation of when tasks may occur. The parallel task table presents a hypothetical UNREP scenario and the tasks that each team member must accomplish at an approximate time in the scenario. A sample of the parallel task table is depicted below in Table 1. When the table is read down a column a sequential list of tasks associated with the chosen watch team member is presented. When the table is read across a row the tasks that each watch team would be in the process of doing at that approximate time is presented. It is like a snap shot of the bridge team interaction at a particular point in time of the UNREP task.

Parallel Task Table				
Time	**Conning Officer**	**Officer Of The Deck**	**Helmsman**	**Lee Helmsman**
02:40	4.5.1.5 - Receive Report That Order Was Executed (Lee Helm)	4.4.2 - Monitor Conning Officer During Maneuver		4.1.3 - Report Pitch/RPM Change To Conning Officer
	4.5.1.5.1 – Acknowledge Report (Lee Helm)			4.1.3.1 - Receive Acknowledgement
	4.5.2.5 - Receive Report That Order Was Executed (Helm)	4.4.2.1 - Correct Conning Officer As Necessary	2.11.1.2 - Report That The Wheel Is Over To The Conning Officer	4.2 - Maintain Ordered Speed **(Loops until new order received)**
	4.5.2.5.1 – Acknowledge Report (Helm)		2.11.1.2.1 - Receive Acknowledgement	2.2 – Maintain Communications **(Periodic Task)**

Table 1: Parallel Task Table of UNREP Task

The index numbers next to each task represent the task's position in the CMN GOMS notation hierarchy. For example, tasks labeled with two digit numbers, such as 4.2, are Functional-Level tasks and other tasks with greater than two digit numbers are sub-tasks of the functional tasks.

IV. TASK OVERVIEW

A. UNDERWAY REPLENISHMENT OVERVIEW

UNREP presents one of the most exhilarating, challenging, and rewarding ship-handling opportunities for a Conning Officer. How precisely a ship can execute an UNREP, both the ship-handling and the deck seamanship aspects of the task, determines what the ship's, as well as the CO's, reputation will become [STAV92].

While on deployment, Navy ships remain at sea for long periods of time ranging from several weeks to several months. Conducting underway replenishments (UNREP), also known as connected replenishments, give the ships the ability to sustain themselves at sea for these long periods by re-supplying fuel, stores, and ammunition. UNREP is a dangerous, but common evolution for Navy ships and is done frequently during deployments, sometimes as often as weekly [NOEL84]. It can also be done at night and in most weather conditions. Essentially, UNREP involves two ships at sea, sometimes three, coming within 90 to 120 feet of each other, while doing 13-15 knots and connecting themselves together with cables that enable stores and fuel to be passed between the ships [CHIE96]. In Figure 6, the replenishment ship is the center ship and is re-fueling the other two ships at the same time.

During a typical UNREP, the replenishment ship is the guide and is charged with maintaining an ordered course and speed; the approach ship initially maneuvers into station 1000 yards astern of the replenishment ship.

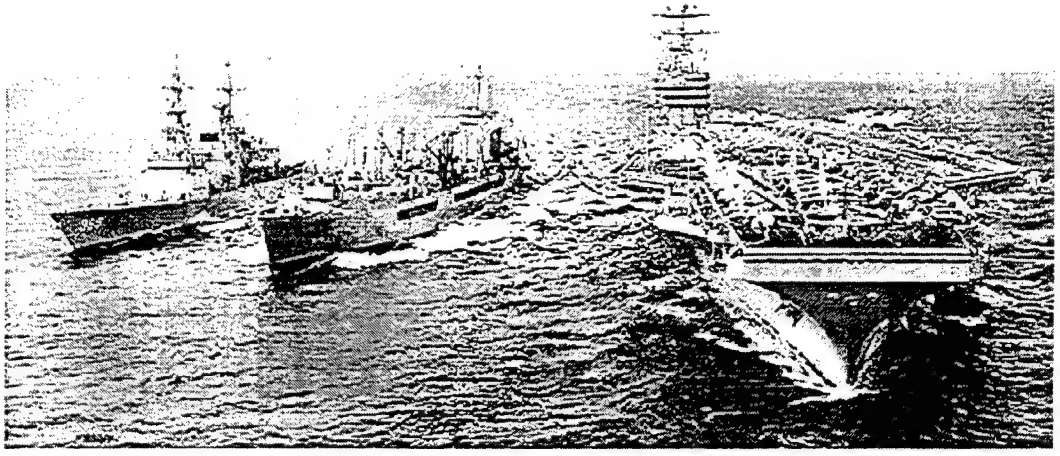


Figure 6: Three ships conducting an Underway Replenishment

However, Aircraft Carriers are a special case. They will normally be the guide ships and therefore the replenishment ship will make the approach on the carrier. The crews of both ships would be working on the decks and at this point would have already spent hours preparing for the cargo transfer portion of the evolution. UNREP is an extremely manpower intensive evolution. The Conning Officer of the approach ship maintains station astern of the replenishment ship as final preparations are done. The Officer of the Deck (OOD) is responsible for ensuring own ship is manned and ready to conduct the UNREP. When all UNREP and engineering stations have reported manned and ready, the OOD will report to the Commanding Officer (CO) and request permission to raise flag ROMEO (for replenishment) to the dip, indicating that the approach ship is

ready to commence the approach. Similar preparation is done on the replenishment ship, however, ROMEO at the dip means that the replenishment ship is steady on ROMEO course and speed and is preparing to receive the approach ship on the side that ROMEO is flying. ROMEO course and speed is the ordered course and speed for the UNREP. The Conning Officer of the approach ship continues to maintain station and observes the course and speed own ship must have ordered to maintain station on the replenishment ship. This course and speed information will be especially useful to the Conning Officer once own ship is alongside the replenishment ship.

When the replenishment ship closes up (raises) flag ROMEO, the Conning Officer of the approach ship receives the cue that it is time to commence the approach. The approach ship must be maneuvered from directly astern of the replenishment ship to a station abreast and parallel to the replenishment ship with between 90 to 120 feet lateral separation. The approach ship must change speed as required to stop on station and to maintain station while alongside. With this goal in mind, the Conning Officer or OOD will order ROMEO closed up on the approach ship to indicate that the ship is commencing its approach. There are several techniques and rules of thumb, for example the Radian Rule, available for the Conning Officer to use to assist in monitoring the ship's progress towards station during the approach phase. Herein the approach phase is defined as the time from when the approach ship starts to move towards station alongside the replenishment ship to when the bow of the approach ship crosses the stern of the replenishment ship. The approach ship's Conning Officer must constantly monitor own

ship's progress and make necessary course and speed corrections. During UNREP it is considered best to control the ship's heading by giving courses to steer in degrees to the Helmsman rather than giving rudder orders [STAV92]. Giving rudder orders is an attempt to do the Helmsman's job and could be dangerous at close ranges. As for speed changes, it is thought to be best for the Conning Officer to give the Lee Helmsman exact revolutions, rather than adding or dropping revolutions [CREN75]. Figure 7 depicts what is known as the coast in method of approach.

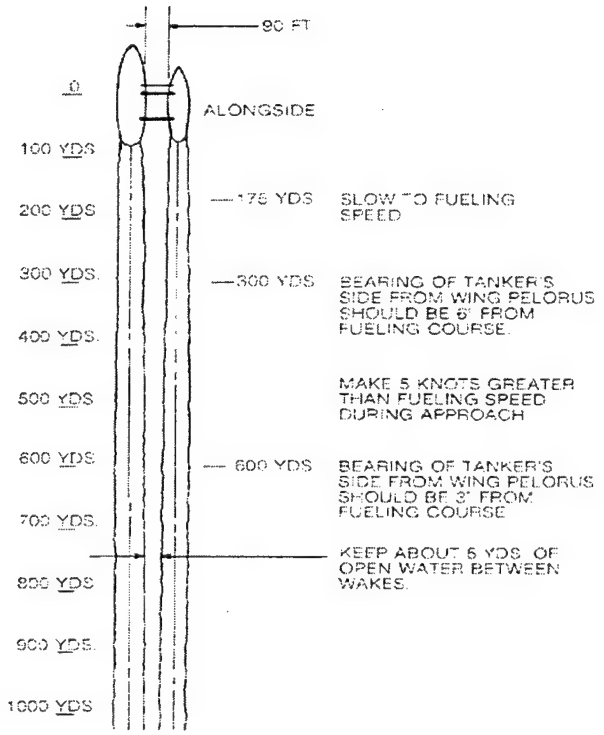


Figure 7: Coast in Approach Method.

Once the bow of the approach ship crosses the stern of the replenishment ship, the alongside phase begins. The first priority for the Conning Officer is to slow own ship to

match the speed of the replenishment ship. The Conning Officer must visualize where own ship should be when on station alongside and estimate how far own ship's momentum will carry it forward after the speed is reduced. When it is time, the Conning Officer will reduce the speed and monitor the affect and if required, adjust speed as necessary to maintain own ship's position alongside. Once the approach ship is alongside on a parallel course, the Conning Officer must maneuver the ship to the exact position necessary for UNREP. This is done by making very slight course and speed changes until on station. Flag ROMEO is hauled down on both ships and shot lines are passed between the ships. The first line across is the phone and distance line that is used for communications between the ships. Notice that in Figure 8, the phone and distance line has colored flags on it that are used by the Conning Officer to judge the lateral separation between the ships [DODG81]. The flags are spaced twenty feet apart and are colored in the following sequence: green, red, yellow, blue, and white. At night chemical lights are added and are spaced at twenty foot intervals.

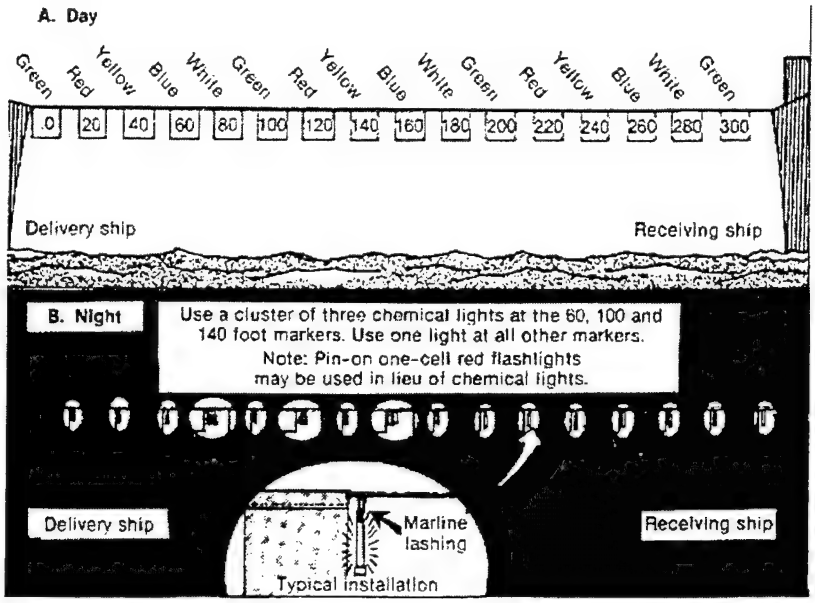


Figure 8: Phone and Distance Line

In order to monitor the ships fore and aft motion, the Conning Officer must pick a set of stanchions or a bulkhead to observe for parallax error [DODG81]. Webster's dictionary defines parallax as the apparent change in direction of an object, caused by a change in observational position that provides a new line of sight. The Conning Officer must use the above mentioned cues to monitor own ship's position for the remainder of the alongside phase, which can last up to several hours. When the high-tension lines are hooked up between the ships and ready to be tensioned, the Conning Officer must inform the Helmsman so that the Helmsman can compensate for the additional force pulling the ships together. The Helmsman must also be notified when de-tensioning lines [STAV92].

The Breakaway phase starts when all fuel and stores transfers are complete. While the crew breaks down the riggings, the Conning Officer continues to maintain station. When all lines are reported clear, the Conning Officer must first verify that all lines are

clear, then ask permission from the CO to commence the breakaway. The Conning Officer usually will increase speed by five to ten knots and hold a parallel course to start the breakaway. After the ship starts to pick up speed, the Conning Officer will give a slight, one to two degree, rudder order away from the replenishment ship. The important cue to monitor at this point is the stern of own ship, as it will move towards the replenishment ship as own ship turns. When own ship's stern is clear of the bow of the replenishment ship, it is safe to freely maneuver.

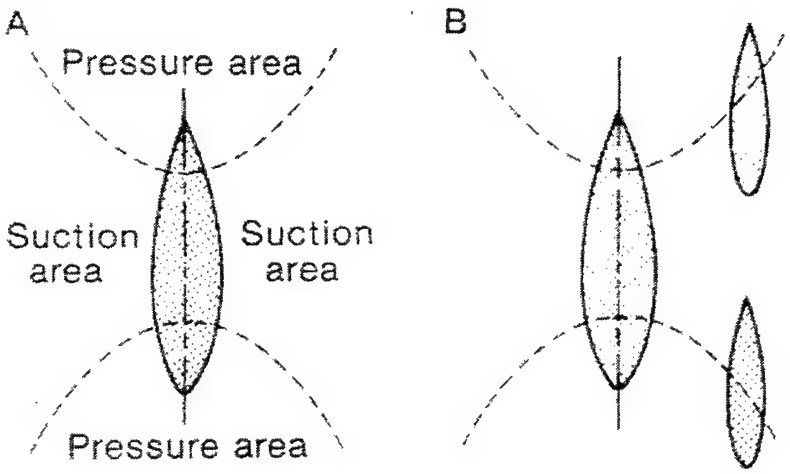
There are three additional factors that can significantly increase the level of difficulty of the alongside phase. First, severe weather conditions make maintaining station extremely difficult. The lateral separation between the ships is normally increased during foul weather and the Helmsman is given more freedom to use the rudder to maintain course. Second, doing a vertical replenishment in conjunction with the connected replenishment adds difficulty. This procedure involves one or two helicopters transferring cargo from the fight deck of the replenishment ship to the vertical replenishment drop zones on the approach ship. Although vertical replenishment does not significantly change the Conning Officer's goals during an UNREP, it does significantly increase the Conning Officer's stress level. And third, it is is very difficult and dangerous for the ships to conduct a turn while they are connected. This procedure is not done very often and requires very precise and slow maneuvers and tremendous coordination between the ships.

B. SHIP HYDRODYNAMICS

Developing a realistic ship-handling simulator requires obtaining physically based hydrodynamic models of each of the ships that will be implemented in the simulator's scenarios. The purpose of this thesis is not to describe a hydrodynamic model. However, some of the basics of ship hydrodynamics and environmental factors relevant to ship handling will be discussed. The focus will be on controllable and uncontrollable forces and the venturi effect.

Controllable forces are the forces that the ship's mechanical components can generate and meter. For most ships these components includes either one or two rudders and propellers. Thus, a ship can control its speed through the water by increasing either its shafts' RPMs or by increasing its propellers' pitch. A ship can slow by reducing or reversing its shafts' RPMs or decreasing its propellers' pitch. Uncontrollable forces are the external forces that act on the ship. They are usually created by nature and are not controllable by the ship. These forces are the result of the wind, current or tide, and are influenced by characteristics of the ship such as its sail area, draft and displacement. At times, uncontrollable forces can make a ship handler's job very difficult and at other times they can be used to give the ship handler an advantage [CREN75].

One uncontrollable force that is significantly increased as two ships pass or travel abreast at a close distance is known as the venturi effect. The venturi effect is the result of the high-pressure zones that are created at the bow and stern and the low-pressure zone created amidships as the ship moves through the water (Figure 9).



Figures 9: Venturi Effect Areas

When ships are alongside each other underway, the venturi effect is compounded due to the intermingling of each ship's high and low pressure areas. This creates suction between the ships that is increased as speed increases, as lateral separation decreases, and as the depth of the water decreases. If two ships get too close to each other, the venturi effect can add just enough suction force to pull the ships together and cause a collision [DODG81].

C. BRIDGE WATCH TEAM MEMBERS

The OOD underway has been designated by the CO to be in charge of the ship and is responsible for the ship's safe and proper operation. The OOD's UNREP related duties include:

- Be aware of the tactical situation and geographic factors that may affect safety of navigation and to take the necessary action to avoid grounding or a collision at sea.

- Obey the navigation rules of the road and the CO's standing orders.
- Supervise and train the Junior Officer of the Deck (JOOD). The JOOD is usually also acting as the Conning Officer.
- Ensure orders to the helm and lee helm are correct to avoid danger, to take or keep an assigned station, and to change course and speed in accordance with orders.
- Make required reports to the CO.
- Supervise the bridge watch team to include: JOOD, Quartermaster, Lookouts, Boatswain Mate, Radar Operators and Messenger.
- Maintain communications with the ship's Combat Information Center and Central Control Station.
- Supervise transmissions and acknowledgements on all tactical voice radio circuits.

The Conning Officer's basic function is to control the movement of the ship by issuing orders to the Helmsman and Lee Helmsman. The Conning officer's Duties during UNREP are:

- Be aware of the tactical situation and geographic factors that may affect safety of navigation and to take the necessary action to avoid grounding or a collision at sea.
- Supervise the Helmsman and Lee Helmsman.
- Ensure everyone on the bridge knows who has the Conn.

- Grant or deny permission for the Helmsman or Lee Helmsman to be relieved.
- Issue necessary orders to the helm and/or lee helm to avoid danger, to take or keep an assigned station, and to change course and speed in accordance with orders.

The last two members of the team are the Helmsman and Lee Helmsman. The Helmsman's main function is to steer the courses prescribed by the Conning Officer. The Helmsman must be Personnel Qualifications Standard (PQS) qualified to stand this watch. The Lee Helmsman's main function is to move the ship's throttle as prescribed by the Conning Officer and to ensure that all bells are correctly answered. The Lee Helmsman must also be PQS qualified to stand this watch.

D. STANDARD COMMANDS

Nowhere are terminology and phraseology as important as they are in the commands given to the Helmsman and Lee Helmsman by the Conning Officer. Because misunderstanding or ambiguity can quickly lead to disaster, there must be no possibility of an order being misinterpreted, and there should be no confusion if standard commands are used. Short cuts and individual variations should be avoided; all enlisted personnel who man the ship's helm or lee helm should become accustomed to receiving commands in the standard format [STAV92].

Standard rudder and engine commands are given in a specific sequence. This sequence is designed to ensure that the order was received correctly and is being carried out. In general, both rudder and engine orders follow this sequence: Command, Reply,

Report and Acknowledgement. Engine orders are simpler than rudder orders, since the only difficult engine order is to have one engine going forward and the other reversed in order to twist the ship. Each class of ship has differences in their engineering plant and thus, requires customized, ship specific, engine orders.

Rudder orders have several variations and the Conning Officer must know which order is required for a given situation. Turns of less than ten degrees are ordered differently then turns greater than ten degrees. Turns can be ordered without the Conning Officer specifying a course to steady on. Again, each class of ship handles differently, and therefore requires some customization as far as degrees of rudder required to turn the ship at various speeds. The *Watch Officer's Guide* is the best reference for standard commands and should be reviewed to ensure that all combinations of commands are modeled in the VE speech recognition system [STAV92].

E. RESTRICTED MANEUVERING

The ship's Restricted Maneuvering Doctrine is followed when the ship will be restricted in its ability to maneuver due to its proximity to land or other ships. Essentially, restricted maneuvering means that the ship has all its engine rooms and steering control stations manned and that critical equipment, such as main engines and generators, are configured for a graceful degradation and/or a quick restoration in the event of a casualty. The restricted maneuvering instruction also provides guidance on casualty control actions that can be taken and procedures for recovering from casualties. The reasoning behind this guidance is that in some cases, such as UNREP, it would be better to keep an

expensive piece of equipment online and let it catastrophically fail, when normally it would be taken off line. This procedure may cause the ship to lose a shaft, but allow enough time for the ship to do an emergency breakaway that could prevent a collision.

Navy ships are built with several levels of redundancy for control systems and critical equipment. Systems of particular relevance to UNREP operations are the main propulsion engines, shafts, generators, and steering equipment. A failure in any one of these systems could easily cause a collision at sea. Typically, when restricted maneuvering is set, personnel man the engine controls on the bridge, the central control station, and locally in the engine rooms. Generators are configured to automatically start and restore power in the event that an online generator fails. Having all stations manned ensures that if a casualty occurs at one level of control, that there will be personnel at the next level down prepared to take control and/or restore from the casualty. As for steering, personnel will man the steering controls on the bridge and in aft steering for immediate recovery from a steering casualty. Before going alongside for an UNREP, the approach ship is required to test its steering controls in their normal as well as backup configuration to ensure all systems are operational. For example, if steering control were lost on the bridge, control would immediately be taken in aft steering. Personnel in aft steering would first try to take electrical control of the rudders and if that failed they would try to take hydraulic control. How well the ship's crew can execute these emergency procedures could be the difference between a collision and no collision.

F. CASUALTIES

The following list of casualties is limited to those that affect the Conning Officer's ability to control the ship and is intended only to provide ideas for ways to increase the level of difficulty of the UNREP scenario. These casualties are not common however. If one occurs, the Conning Officer must take immediate action to prevent a collision or prepare for a collision. The indicators, effects, and possible corrective actions listed below may not be complete and will vary from ship class to ship class.

- Loss of a shaft

  Indicators: Ship's speed starts to slow, erratic shaft RPM indicator readings, report of loss of one or more engines or a hot line shaft bearing.

  Effects: Ship's max speed may be reduced, responsiveness to speed changes may be reduced.

  Possible corrective action: Increase the RPMs on the remaining shaft and conduct an emergency breakaway. The Helmsman may also have to compensate for the drag of the failing shaft.

- Loss of gyrocompass or repeater

  Indicators: Heading displayed on the gyrocompass does not change or changes erratically, gyrocompass failure alarm sounds.

  Effects: Gyrocompass and repeaters are unavailable for steering the ship.

Possible corrective action: Helmsman and Conning Officer must use the magnetic compass to steer the ship.

- Loss of controllable reversible pitch (CRP) propeller control

  Indicators: Report that CRP control was lost, ship does not respond to changes of speed.

  Effects: Ship's max speed may be reduced, responsiveness to speed changes may be reduced.

  Possible corrective action: Change the RPMs on the remaining shaft to control the speed and conduct an emergency breakaway. The Helmsman may also have to compensate for the drag of the failing CRP propeller.

- Loss of steering controls

  Indicators: Ship does not respond to steering changes, steering alarm sounds, report that steering equipment failed.

  Effects: Loss of steering control of the ship.

  Possible corrective action: Steering equipment may be changed to alternate equipment, usually by pushing a button on the bridge. Steering control may be taken in aft steering either electrically or hydraulically. Conduct an emergency breakaway.

- Loss of one or more main engines

  Indicators: Ship's speed starts to slow, ·atic shaft RPM indicator readings, report of loss of one or more engines.

  Effects: Ship's max speed may be reduced, responsiveness to speed changes may be reduced.

  Possible corrective action: Increase the RPMs on the remaining engines and conduct an emergency breakaway. The Helmsman may also have to compensate for the drag of the slowing shaft.

The standard procedure for any one of the above casualties is to conduct an emergency breakaway, which is the same as a normal breakaway except an emergency breakaway is done faster. The objective of an emergency breakaway is to quickly break down the rigs connecting the ships without severely damaging equipment or injuring personnel. NWP 4-01.4 contains the details of how an emergency breakaway is executed [CHIE96]. Additionally, each ship will have a restricted maneuvering doctrine and engineering casualty control procedures for each of the listed casualties.

V. THE TASK ANALYSIS

A. TASK ANALYSIS OF A CONNING OFFICER DURING UNREP

Analyzing the tasks a Conning Officer must perform during an UNREP was the primary goal of this thesis and therefore receives the most detailed analysis of the bridge team members. The following analysis was constructed in the spirit of CMN GOMS notation. However, the embedded narrative was included to provide an explanation of the tasks and the framework in which they occur. Each goal will be explained in the narrative and the GOMS notation will follow. A copy of the task analysis without the narrative can be found in Appendix A.

The analysis was broken into three levels, first the Unit-Task Level, second the Functional Level and third the Detailed Level (Argument Level). As the analysis progresses from the Unit-Task Level to the Detailed Level, more detail is captured in each successive level.

1. Unit Task Level Analysis

The Unit-Task Level model shows that the primary goal is to execute an UNREP. To accomplish this goal the following four sub-goals must be achieved in order: complete the brief phase, complete the approach phase, complete the alongside phase, and finally completing the breakaway phase. Using CMN GOMS notation these goals are represented as follows:

goal: Execute_UNREP

. goal: Complete_Brief_Phase

. goal: Complete_Approach_Phase

. goal: Complete_Alongside_Phase

. goal: Complete_Breakaway_Phase

2. Functional Level Analysis

Decomposing the Unit-Task into its functional components developed the Functional Level model. The functional components are the sub-goals or methods that must be accomplish before higher level goals can be achieved. For example, all the sub-goals below the goal Complete_Approach_Phase, such as Know_UNREP_Plan and Maintain_Communications, must be completed before the higher level Complete_ Approach_Phase goal can be achieved.

Contrary to standard CMN GOMS notation, which best represents a serial task sequence, the analysis notation used here does not necessarily represent a serial sequence of sub-goals leading to a higher level goal. Instead, the subtasks in this notation could be accomplished in many different sequences. Some tasks may, and in fact will, loop for a significant period of time while other tasks may be repeated quickly and sporadically throughout a given phase. Situations when a task loops for some period or when a task reoccurs several times will be noted as they occur in the narrative of the detailed level analysis that follows later in this chapter.

goal: Execute_UNREP

. goal: Complete_Brief_Phase

. . goal: Know_UNREP_Plan

. goal: Complete_Approach_Phase

. . goal: Know_UNREP_Plan

. . goal: Maintain_Communications

. . goal: Maintain_Awareness_Of_Third_Party_Ships

. . goal: Maintain_Station

. . goal: Receive_Report_Own_Ship_Ready_To_Go_Alongside

. . goal: Make_Approach

. goal: Complete_Alongside_Phase

. . goal: Determine_When_Bow_Crosses_Stern

. . goal: Watch_For_Bow_To_Be_Pushed_Away_From_Replenishment_Ship

. . goal: Monitor_Venturi_Effect_Alongside_Replenishment_Ship

. . goal: Determine_Lateral_Separation

. . goal: Determine_Range_To_Station_Closing_Rate

. . goal: Determine_When_To_Match_Speeds

. . goal: Maneuver_Close_To_Station_Alongside

. . goal: Get_Phone_And_Distance_Line_Across

. . goal: Maintain_Station_Alongside

. goal: Complete_Breakaway_Phase

. . goal: Maintain_Station_Alongside

. . goal: Determine_All_Lines_Clear

. . goal: Receive_Breakaway_Order_From_CO

. . goal: Breakaway

. . goal: Go_To_Next_Station_Or_Duties_Assigned

3. Detailed Level Analysis

The Detailed Level model was developed by further decomposition of the Functional Level methods into smaller more detailed methods that were required to achieve the higher level goal. In many cases, the methods themselves can be viewed as the sub-goals of sub-goals. Throughout this analysis the Conning Officer may, in some cases, choose to select one method or a combination of several methods to achieve a goal. Recall that for this analysis the notation is intended to allow tasks to loop and/or reoccur several times throughout the UNREP. Each Conning Officer develops their driving skills under a different CO's tutelage and encounters various individual experiences throughout their careers that influence the ship handling strategies they develop as well as the cues that they use to drive. It would be exceptionally difficult to analyze every possible sequence of goals that could lead to a successful UNREP. Thus, this analysis documents the general goals that must be accomplished to complete an UNREP regardless of sequence and the cues necessary to achieve these goals.

Some tasks are repeated many times throughout an UNREP. Instead of repeating all of the details related to a particular task over and over in the Detailed Level analysis, the details of a task will appear only once in the analysis. When a task is repeated later in the analysis, the task will have the same goal name. For example, the goal Turn_Ship occurs several times throughout the analysis. However the details related to this task appear only once. All other occurrences are simply references to the Turn_Ship method. The reader can refer back to the first occurrence of a goal as necessary for review.

The goal for a Conning Officer is to safely and efficiently execute an UNREP maneuver. The following analysis and the accompanying narrative documents the sub-goals and methods required to accomplish the Execute_ UNREP goal.

goal: Execute _UNREP

The Complete_ Brief_ Phase was the first goal to be dealt with. This goal is generally accomplished during the operations brief the night before an UNREP or at least there should be a UNREP brief several hours before the UNREP is to occur. All available officers and other personnel who are involved in the UNREP will normally attend these briefs. At a typical UNREP brief, an officer, usually the First Lieutenant, will present a plan detailing what will take place during the UNREP. Details that the Conning Officer must remember are the rendezvous time, ROMEO course and speed, predicted weather, stores and fuel to be transferred, side of approach, and estimated time alongside as well as a picture of the replenishment ship's UNREP stations compared to own ship's UNREP stations. The purpose of the picture is to show the Conning Officer which stations must

be lined up across from each other so that lines and hoses can be passed from station to station between the ships. At this brief, the CO may specify a particular strategy he wants to use during the UNREP maneuver or he may mention particular concerns related to weather or sea-state. Usually the CO will discuss previous experiences he has had while going alongside the replenishment ship or maybe a lack of experience with a particular replenishment ship or ship-class.

Other important information that must be known before going to the bridge to Conn the ship is the engineering plant configuration. Some of the information the Conning Officer should remember about the plant configuration includes the main engines or boilers online, which shafts are turning, which generators are online, as well as the steering motors and cables online. As previously mentioned, in most cases, all engines will be online with all shafts turning so that full power is available. Auxiliary equipment such as generators, motors, and pumps will be configured to provide the quickest casualty recovery time possible. Engineering department personnel will be at restricted maneuvering stations for the entire UNREP to provide immediate casualty recognition and recovery. The Complete_Brief_Phase sub-goals discussed above are represented as follows in CMN GOMS notation:

. goal: Complete_Brief_Phase

. . goal: Know_UNREP_Plan

. . . [select: Go_To_OPS_Brief

. . . Go_To_CIC_Before_Watch

. . . Receive_UNREP_Brief_On_Bridge]

. . . goal: Know_Plant_Configuration

. . . . [select: Go_To_OPS_Brief

. . . . Go_To_CCS_Before_Watch

. . . . Receive_UNREP_Brief_on_Bridge]

The goal Complete_Approach_Phase represents the time from when the approach ship arrives at either life guard station 1000 yards astern or waiting station 500 yards astern of the replenishment ship to the time the approach ship's bow crosses the plane perpendicular to the stern of the replenishment ship. By this time, it is critical that the Conning Officer knows the UNREP plan. A well-prepared Conning Officer will have mentally rehearsed the details of the UNREP maneuver before arriving on the bridge. It is always prudent to double-check and ensure that the UNREP plan has not changed and that it is being followed.

For the remainder of the task analysis these assumptions were made:

- An UNREP brief has been completed.
- Restricted maneuvering is set.
- Own ship has just arrived on station astern of the replenishment ship.
- Own ship will approach on the replenishment ship's starboard side.
- ROMEO corpen is 140 degrees true.
- ROMEO speed is 13 knots.
- All engines are online and full power is available.

- The CO, Conning Officer and OOD are on the port bridge wing watching for ROMEO to be closed up on the replenishment ship.
- The Helmsman and Lee Helmsman are fully qualified and standing at the Ship's Control Console in the center of the bridge.
- The sea-state is three and the weather forecast is good.
- The approach ship is an Aegis cruiser with two controllable, reversible pitch propellers.

The above discussion provides all the preliminary information that a Conning Officer should posses prior to conning the ship. The following analysis steps through the approach phase of an UNREP. The Know_UNREP_Plan and Know_Plant_Configuration goals are repeated here because they should be reconfirmed prior to taking the Conn.

. goal: Complete_Approach_Phase

. . goal: Know_UNREP_Plan

. . . goal: Determine_Side_To_Approach_On

. . . . [select: Observe_ROMEO_Flag_On_Replenishment_Ship

. . . . Recall_From_Brief

. . . . Radio_Communication_With_Replenishment_Ship]

. . . goal: Know_Plant_Configuration

. . . . [select: Call_CCS_From_Bridge

. . . . Ask_Lee_Helm_To_Get_Configuration_From_CCS]

. . . goal: Go_To_Bridge_Wing

. . . . goal: Determine_Which_Bridge_Wing

. . . . . Chose_Side_That_Will_Be_To_Replenishment_Ship

Maintaining communications between the Conning Officer, Helmsman, Lee Helmsman and the CO is very important. Normally, communications between the Conning Officer, the Helmsman, and Lee Helmsman is via an amplified speaker system, however, other methods may be used if this system fails.

. . goal: Maintain_Communications ...periodic task

. . . [select: Use_Amplified_Communications_System

. . . Yell_Through_Hatch ...if amp fail/not available

. . . Visual_Expressions ...for comms. with CO, OOD

. . . Verbal_Communications

. . . Use_Relay_Person] ... if amp fail/not available

. . . Verify_Order_Received

The Conning Officer must periodically visually scan the horizon to detect and track other ships in the area. During an UNREP, the Conning Officer's attention is dedicated to getting to station and/or maintaining station, so the time spent tracking other ships is limited. Thus, the OOD usually maintains the surface contact picture and updates the Conning Officer and CO periodically. This task can usually be accomplished very quickly and is repeated frequently throughout the entire UNREP as often as other tasks permit.

. . goal: Maintain_Awareness_Of_Third_Party_Ships ...periodic task

. . . [select: Visually_Scan_Horizon

. . . Listen_For_Contact_Reports

. . . Ask_OOD_About_Contacts]

One distinguishing characteristic of a good Conning Officer is the ability to precisely maintain an ordered station. Constant vigilance is required to maintain station. Therefore, the Conning Officer must constantly observe own ship's position relative to the guide ship (the replenishment ship in this case) and make the necessary speed and course corrections to stay on station. How does one know when to make a correction? By observing cues that answer questions such as: Is own ship closing/opening the range to the replenishment ship? Is own ship drifting to the right or left of station? In order to detect these cues, the Conning Officer must maintain an up to date range by regularly requesting the range from the stadometer operator or radar operator and frequently shoot bearings to the replenishment ship. Once on station, it is important that the Conning Officer remember the speed and RPMs required to maintain the exact speed of the replenishment ship. This information will be important when own ship is alongside trying to match the replenishment ship's speed. Other cues available include observing the masts of the replenishment ship; they should line up if own ship is directly astern. At night a similar cue can be used except in this case the masthead lights should line up. Another cue to watch is the wake of the replenishment ship; own ship should be centered in the wake if it is directly astern. If own ship is more than a couple of degree left/right or 20

yards out of station, the Conning Officer should take action (turn or change speed) to get back to station.

. . goal: Maintain_Station ...loops until Make_ Approach executed

. . . goal: Shoot_Bearing_To_Replenishment_Ship ...frequently until alongside

. . . . [select: Use_Alidade_On_Bridge_Wing

. . . . Use_Radar_Bearing_To_Replenishment_Ship

. . . . Replenishment_Ship's_Masts_Lineup

. . . . Masthead_Lights_Of_Replenishment_Ship_Lineup ...at night

. . . . Own_Ship_In_Wake_Of_UNREP_Ship] ...at night/low vis

. . . goal: Get_Range_To_Replenishment_Ship ...frequently until alongside

. . . . [select: Get_Range_From_Stadimeter

. . . . Call_For_Radar_Range ...anytime and at night/low visibility

. . . . Visual_Estimate] ...in between updates

. . . goal: Determine_If_On_Station

. . . . goal: Determine_If_Range_To_Replenishment_Ship_Correct

. . . . . Compare_Range_With_Ordered_Range

. . . . goal: Determine_If_Bearing_To_Replenishment_Ship_Correct

. . . . . Compare_Bearing_With_Ordered_Bearing

. . . Verify_On_Station

If own ship is not on station, the Conning Officer must change course and speed as required to get to station and stay there. The methods required to Turn_Ship, Change_

Speed_Of_ Ship and Monitor_Helm are explained later in the Detailed Level analysis of the Complete_Approach_Phase.

. . . goal: Make_Necessary_Corrections ...loop back to Maintain_Station

. . . . [select goal: Turn_Ship ...see page 58

. . . . goal: Change_Speed_Of_Ship] ...see page 55

The ready to go alongside report is important since it determines when own ship can hoist ROMEO at the dip, indicating it is ready to commence its approach. Since flag signals are the normal mode of communications, it is essential that own ship expediently hoist flag ROMEO to the dip when it is ready to make its approach.

. . goal: Receive_Report_Own_Ship_Ready_To_Go_Alongside

. . . Receive_Verbal_Report_From_OOD

. . . goal: Acknowledge_Receiving_Report

. . . . Verbally_Repeat_Order_Received

. . . goal: Order_ROMEO_Raised_On_The_Side_To_Go_Alongside

. . . . Order_Signalman_To_The_Dip_ROMEO ...OOD may do this

The next signal that must be received from the replenishment ship is ROMEO close up on the side own ship is to approach. On the CO's order, own ship would answer by closing up ROMEO and commencing its approach. At night, flashing light signals will be used and in a few cases, normally only emergencies, a radio may be used.

. . goal: Make_Approach

. . . goal: Observe_ROMEO_Close-up_On_Replenishment_Ship

. . . . [select: Observe_ROMEO_Move_Up_On_Replenishment_Ship

. . . . Observe_Flashing_Light_Signal ...at night/low visibility

. . . . Receive_Radio_Transmission] ...at night/low visibility

. . . goal: Receive_Approach_Order_From_CO

. . . . [select: Receive_Verbal_Order_From_CO_To_Commence_Approach

. . . . Receive_Verbal_Order_Via_XO_To_Commence_Approach

. . . . Receive_Verbal_Order_Via_OOD_To_Commence_Approach]

. . . . goal: Acknowledge_Receiving_Order

. . . . . Verbally_Acknowledge_Order_Received

. . . goal: Order_ROMEO_Raised_On_The_Side_To_Go_Alongside

. . . . Order_Signalman_To_Close-up_ROMEO ...OOD may do this

Since it is a good rule of thumb to increase speed first before turning, the Conning Officer will first verbally issue an engine order that will increase the speed of the ship [STAV92]. Generally, the CO will prescribe the approach speed. However, NWP 4-01.4 recommends using five knots over the speed of the replenishment ship. As previously mentioned, the Conning Officer, Helmsman, and Lee Helmsman must follow a very specific standard command sequence when issuing engine and rudder orders.

. . . goal: Change_Speed_Of_Ship ...commence approach

. . . . goal: Issue_Engine_Order ...to lee helmsman

. . . . . [select goal: Increase_Speed

. . . . . . goal: Determine_Desired_Speed

. . . . [select: Use_Predetermined_Speed_From_UNREP_Brief

. . . . Use_Speed_CO_Orders

. . . . Use_Safe_Speed_For_Current_Weather_Conditions]

. . . . . . goal: Give_Verbal _Order_To_Lee_Helm

. . . . . goal: Decrease_Speed

. . . . . . goal: Determine_Desired_Speed

. . . . [select: Use_Predetermined_Speed_From_UNREP_Brief

. . . . Use_Speed_CO_Orders

. . . . Use_Safe_Speed_For_Current_Weather_Conditions]

. . . . . . goal: Give_Verbal_Order_To_Lee_Helm]

. . . . goal: Receive_Repeat-back_From_Lee_Helm

. . . . . Listen_For_Repeat-back_From_Lee_Helm

. . . . . [select goal: Acknowledge_Repeat-back ...if received

. . . . . goal: Repeat_Order] ...if not received

There are a number of cues that can be used to determine that an order is being executed. For example, if the ship's speed is being increased, there may be a noticeable change in the sound of the turbines. If the increase in speed was significant, an increase of the relative wind speed felt on the bridge wing or a change in the feel of the ship's hull cutting through the water may be noticed. As a last resort, speed indicators are usually located on the bridge as well as on each of the bridge wings so that the Conning Officer can monitor changes in speed.

. . . . goal: Determine_If_Order_Was_Executed

. . . . . [select: Listen_For_Change_In_Engine_Sound

. . . . . Observe_Range_To_Replenishment_Ship_Close

. . . . . Observe_Target_Angle_Of_Replenishment_Ship_Change

. . . . . Observe_Feeling_Speed_Increase

. . . . . Observe_RPM_Indicator

. . . . . Observe_Increase_On_Speed_Indicator]

. . . . goal: Receive_Report_That_Order_Was_Executed

. . . . . Listen_For_Report_From_Lee_Helm

. . . . . [select goal: Acknowledge_Report ...if received

. . . . . goal: Request_Status_Of_Order_Execution] ...if not received

When turning the ship, it is particularly important to be aware of what other ships in the area are doing. The Conning Officer should personally visually verify the water in the direction own ship will turn is clear of other shipping or request that someone else verify the area is clear [STAV92]. Next, the Conning Officer must consider several questions before issuing a rudder order. What direction to turn? How quickly should the ship turn? How many degrees will the ship's heading change during the turn? How fast is the ship moving? The answers to these questions will help the Conning Officer determine how much rudder is required to achieve the intended result. With experience, answering these questions for oneself becomes almost automatic. There are two philosophies on how a Conning Officer should turn a ship. When using the first method, the Conning

Officer tries to control the rudder by issuing specific rudder orders to the Helmsman such as, "Right five degrees rudder". This method, in effect, takes control of the rudder from the Helmsman since the Helmsman must follow the Conning Officer's orders exactly and can not automatically counter the swing of the ship or decrease the amount of rudder to slow the turn of the ship. To execute this method well requires a great deal of experience. When using the second method, the Conning Officer typically issues new courses for the Helmsman to steer. For example, "Come right, steer course 145". This method usually decreases the chances that the Conning Officer will over shoot an intended course by leaving the rudder over for too long. In this case, the Helmsman knows what heading to go to and has more freedom to use the rudder to check the swing in time to stop on the ordered course [STAV92]. Most Conning Officers probably use a method somewhere in between these two extremes.

For analysis purposes, at this point, assume the Conning Officer has increased speed by five knots and issued a rudder order such as "Come right, steer course 145". The Helmsman immediately repeats the order back to the Conning Officer and later reports when the order is completed. Own ship has started to slowly pull out to the right and has closed to 900 yards astern of the replenishment ship. Another rule of thumb that can be used is called the rule of thirty, which means that the total of the ship's speed, in knots, and the degree of rudder ordered should not exceed thirty. This should prevent the ship from heeling over excessively during turns.

. . . goal: Turn_Ship ...to change lateral separation

. . . . goal: Visually_Verify_Direction_Of_Turn_Clear

. . . . . [select: Walk_To_Bridge_Wing_Of_The_Direction_Of_Turn_To_Look

. . . . . Request_Another_Watch_Team_Member_Visually_Check]

. . . . goal: Issue_Rudder_Order ...to helmsman

. . . . . [select goal: Starboard_Turn

. . . . . . goal: Determine_How_Far_To_Turn

. . . . [select: Use_Prior_Experience_To_Estimate_Distance

. . . . Use_Radian_Rule_To_Monitor_Turn

. . . . Follow_CO's_Orders]

. . . . . . goal: Determine_Degree_of_Rudder_To_Use

. . . . [select: Use_The_Rule_Of_Thirty_To_Determine_Amount

. . . . Use_Prior_Experience_To_Estimate_Amount

. . . . Follow_CO's_Orders]

. . . . . . goal: Give_Verbal_Order_To_Helm

. . . . . goal: Port_Turn

. . . . . . goal: Determine_How_Far_To_Turn

. . . . [select: Use_Prior_Experience_To_Estimate_Distance

. . . . Use_Radian_Rule_To_Monitor_Turn

. . . . Follow_CO's_Orders]

. . . . . . goal: Determine_Degree_of_Rudder_To_Use

. . . . [select: Use_The_Rule_Of _Thirty_To_Determine _Amount

. . . . Use_Prior_Experience_To_Estimate_Amount

. . . . Follow_CO's_Orders]

. . . . . . goal: Give_Verbal_Order_To_Helm]

. . . . goal: Receive_Repeat-back_From_Helm

. . . . . Listen_For_Report_From_Helm

. . . . . [select goal: Acknowledge_Repeat-back ...if received

. . . . . goal: Repeat_Order] ...if not received

The Conning Officer monitors the Helmsman and the turn in progress by watching the rudder angle indicator to see that the rudder was turned in the correct direction by the ordered amount. Additional cues that can be used to monitor a turn include observing the feeling of the ship starting to heel, the wake of the replenishment ship, the gyrocompass heading change, the feeling that the ship is turning, and the rate at which the ship is turning. The rate at which the ship is turning is important because if the ship is turning quickly as it is approaching the ordered course, the Helmsman may need to be reminded not to let the ship stray past the ordered heading. Notice that many of the cues used to detect that a turn order has been executed are identical to the cues used to monitor a turn.

. . . . goal: Determine_If_Order_Was_Executed

. . . . . [select: Observe_Rudder_Angle_Indicator

. . . . . Observe_Wake_Of_Replenishment_Ship

. . . . . Observe_Feeling _Ship_Heel

. . . . . Observe_Target_Angle_Of_Replenishment_Ship_Change

. . . . . Observe_Horizon

. . . . . Observe_Wake_Of_Own_Ship

. . . . . Observe_Gyrocompass_Heading_Change

. . . . . Observe_Feeling_That_Ship_Is_Turning]

. . . . goal: Receive_Report_That_Order_Was_Executed

. . . . . Listen_For_Report_From_Helmsman

. . . . . [select goal: Acknowledge_Report ...if received

. . . . . goal: Request_Status_Of_Order_Execution] ...if not received

. . . goal: Monitor_Ship's_Turn

. . . . [select: Observe_Rudder_Angle_Indicator

. . . . Observe_Feeling_Ship_Heel

. . . . Observe_Wake_Of_Replenishment_Ship

. . . . Observe_Wake_Of_Own_Ship

. . . . Observe_Horizon

. . . . Observe_Gyrocompass_Heading_Change

. . . . Observe_Feeling_That_Ship_Is_Turning

. . . . Observe_Rate_Of_Turn_ Increase/ Decrease]

. . . . goal: Monitor_Helmsman

. . . . . [select: Observe_Turn_Progress_On_Gyrocompass

. . . . . Observe_Rudder_Angle_Indicator]

While monitoring the turn, the Conning Officer may find it necessary to make corrections. For instance, the previous order may not have caused the intended result or the desired outcome may have changed. The goals discussed in the above analysis provide insight into the methods used to determine if a correction is required. All that is left is to issue another engine/rudder order and monitor for the desired result. This process of giving orders and waiting to see the result is repeated throughout the approach.

. . . goal: Make_Necessary_Corrections

. . . . . [select goal: Turn_Ship

. . . . . goal: Change_Speed_Of _Ship]

The Helmsman reports to the Conning Officer when the ship is steady on the ordered course. As the range to the replenishment ship continues to close, the Conning Officer must frequently update range and bearing as well as monitor the lateral separation. The most common tool used to determine lateral separation is the Radian Rule. By using the Radian Rule, the Conning Officer can quickly determine if own ship has progressed towards or over shot the desired lateral separation. On the other hand, some Conning Officers may choose to simply use seaman's eye to judge lateral separation.

. . . goal: Receive_Steady_On_Course_Report

. . . . Listen_For_Steady_On_Course_Report

. . . . [select goal: Acknowledge_Report ...if received

. . . . goal: Request_Status_Of_Order_Execution] ...if not received

. . . goal: Get_Range_To_Replenishment_Ship

. . . . [select: Get_Range_From_Stadimeter

. . . . Call_For_Radar_Range]

. . . . goal: Determine_Range_Closing/Opening_Rate ...relative speed

. . . . . [select: Call_For_Current_Speed

. . . . . Observe_Speed_Indicator

. . . . . Estimate_Closing_Rate]

. . . goal: Shoot_Bearing_To_Replenishment_Ship

. . . . [select: Use_Alidade_On_Bridge_Wing

. . . . Call_For_Radar_Bearing] ...at night/low visibility

As the range to the replenishment ship decreases to within the last hundred yards, it is paramount that the Conning Officer accurately judges that the lateral separation is enough to safely proceed alongside. At this point, a minimum of eighty feet lateral separation is comfortable. If the lateral separation becomes too narrow it would be prudent for the approach ship to slow and increase the lateral separation before crossing the stern of the replenishment ship. Rather than approaching too close, it is safer to end up alongside with too much lateral separation and have to slowly close to within the desired separation.

. . . . goal: Determine_Range_Closing/Opening_Rate ...relative speed

. . . . . [select: Call_For_Current_Speed

. . . . . Observe_Speed_Indicator

. . . . . Estimate_Closing_Rate]

. . . goal: Shoot_Bearing_To_Replenishment_Ship

. . . . [select: Use_Alidade_On_Bridge_Wing

. . . . Call_For_Radar_Bearing] ...at night/low visibility

. . . goal: Determine_If_Lateral_Separation_Closing/Opening/Maintaining

. . . . [select: Use_Radian_Rule_Method

. . . . Use_Table_Of_Radian_Rule_Values_Method

. . . . Observe_Distance_Between_Wakes

. . . . Use_Seaman's_Eye_Method ...requires experience

. . . . Use_Combination_Of_The_Above]

. . . goal: Determine_If_Lateral_Separation_Too_Close/Far

. . . . [select: Use_Radian_Rule_Method

. . . . Use_Table_Of_Radian_Rule_Values_Method

. . . . Observe_Distance_Between_Wakes

. . . . Use_Seaman's_Eye_Method ...requires experience

. . . . Use_Combination_Of_The_Above]

. . . . goal: Make_Necessary_Corrections

. . . . . [select goal: Turn_Ship

. . . . goal: Change_Speed_Of_Ship]

The last chance to determine that the lateral separation is safe is right before the bow of own ship crosses the stern of the replenishment ship. This is also the beginning of

the alongside phase of the UNREP. There are no instruments available that accurately determine distance this close. The Conning Officer must rely on past experience and depth perception to estimate the distance between the ships.

. . . goal: Determine_If_Lateral_Separation_Is_Safe_To_Go_Alongside

. . . . Visually_Estimate_Lateral_Separation

. . . . goal: Make_Necessary_Corrections ...if not safe

. . . . . [select goal: Turn_Ship

. . . . . goal: Change_Speed_Of_Ship]

. . . goal: Monitor_Bow_As_It_Approaches_Replenishment_Ship's_Stern

. . . . Watch_For_Pressure_To_Push_Bow_Away_From_Stern

Water pressure at the stern of the replenishment ship and the bow of own ship causes a high-pressure area that may initially cause the bow of own ship to be pushed away from the stern of the replenishment ship. However, as own ship continues to gain on the replenishment ship, the high-pressure zones interact and cause a venturi effect between the ships. The venturi effect causes a suction to form that tends to pull the ships together. The closer the ships are, the stronger the suction force between them. Thus, it is extremely important to observe the lateral separation between the ships, particularly watching for a decreasing trend. Again, there are no instruments used to monitor separation other than the Conning Officer's eye.

. goal: Complete_Alongside_Phase

. . goal: Determine_When_Bow_Crosses_Stern

. . . Visually_Estimate

. . goal: Watch_For_Bow_To_Be_Pushed_Away_From_Replenishment_Ship

. . . Observe_Bow_Motion ...high pressure area between bow and stern

. . goal: Monitor_Venturi_Effect_Alongside_Replenishment_Ship ...< 80 feet

. . . goal: Monitor_Lateral_Separation_Distance

. . . . [select: Observe_Wake_Action_Between_Ships

. . . . Visually_Estimate_Opening/Closing_Trend

. . . . Visually_Estimate_Lateral_Separation]

. . . . goal: Make_Necessary_Corrections ...if too far or close

. . . . . [select goal: Turn_Ship

. . . . . goal: Change_Speed_Of_Ship]

The next major step for the Conning Officer is to determine when to match the replenishment ship's speed. Previous experience with the same replenishment ship is very helpful here, otherwise, one must estimate when to cut own ship's speed. The main thing to consider is how far will own ship surge (continue to move ahead) after its speed has been reduced. Again, experience is crucial. If the speed is reduced too early, the Conning Officer will have to try to catch-up to get into station. On the other hand, if the speed is left on too long, own ship will shoot past the intended station and have to slowly fall back to get into station. A cue that can be used to help judge the relative speed between the ships is the speed at which items on the replenishment ship appear to pace. Using this cue

makes it easier to detect when own ship is moving too fast or too slow. The process of initially getting into station typically requires several slight speed and course changes.

. . goal: Determine_Lateral_Separation ...>90 feet

. . . [select: Observe_Wake_Action_Between_Ships

. . . Visually_Estimate_Lateral_Separation_Distance]

. . . goal: Make_Necessary_Correction ...if too far or close

. . . . [select goal: Turn_Ship

. . . . goal: Change_Speed_Of_Ship]

. . goal: Determine_Range_To_Station_Closing_Rate

. . . goal: Determine_Range_To_Station

. . . . [select: Visually_Estimate_Distance

. . . . Observe_Rate_Which_Features_On_Replenishment_Ship_Pass]

. . . goal: Make_Necessary_Correction ...if too fast or slow

. . . . [select goal: Turn_Ship

. . . . goal: Change_Speed_Of_Ship]

. . goal: Determine_When_To_Match_Speeds

. . . Compare_Speed_Between_Ships_Estimate_When_To_Match_Speed

. . . . goal: Change_Speed_Of_Ship

. . goal: Maneuver_Close_To_Station_Alongside

. . . goal: Monitor_Ships_Heading_On_Gyrocompass ...repeats frequently

. . . . Observe_Bridge_Wing_Gyrocompass

. . . goal: Monitor_Lateral_Separation

. . . . [select: Observe_Wake_Between_Ships

. . . . Visually_Estimate_Opening /Closing_Trend]

. . . goal: Monitor_Fore_And_Aft_Motion

. . . . [select: Use_Replenishment_Ship's_Riggings_As_Range

. . . . Use_Replenishment_Ship's_Bulkhead_As_Range]

. . . goal: Make_ Necessary_Correction ...to move towards station

. . . . [select goal: Turn_Ship

. . . . goal: Change_Speed_Of_Ship]

When own ship is close to station, it is time to have the phone and distance line passed. Once the phone and distance line is in place, it becomes much easier to determine the lateral separation. The Conning Officer should use the flags on the phone and distance line to determine the necessary course changes required to maneuver own ship to the ordered lateral separation. Next, or at the same time, the Conning Officer should maneuver the ship as required to ensure that the UNREP stations on each of the ships are across from each other. When the UNREP stations are inline, the Conning Officer should look for riggings or a bulkhead on the replenishment ship to use as a cue to maintain station. For example, the Conning Officer may pick two rigs on the replenishment ship to line up and then watch for parallax error to occur. This would indicate that own ship has pulled ahead of the replenishment ship or fallen behind. Once own ship is on station, the Conning Officer must constantly monitor the flags on the phone and distance line and the

rigs on the replenishment ship in order to maintain station. Whenever lines are tensioned or de-tensioned, the Conning Officer should inform the Helmsman, so that the Helmsman is ready to compensate for the increased force of the lines pulling own ship towards the replenishment ship. The process described for maintaining station would be repeated for hours. Normally, while alongside, the Conning Officer will be replaced several times. This provides experience for more officers and is meant to keep the Conning Officer alert.

. . goal: Get_Phone_And_Distance_Line_Across ...when near station

. . . Give_Order_To_Send_Phone_And_Distance_Line_Across

. . goal: Maintain_Station_Alongside ...loop until All Lines Clear

. . . goal: Monitor_Lateral_Separation

. . . . [select: Observe_Flags_On_Phone_And_Distance_Line_Open/Close

. . . . Visually_Estimate_Opening/Closing_Trend

. . . . Observe_Chemical_Lights_On_Phone_And_Distance_Line]

. . . goal: Monitor_Fore_And_Aft_Motion

. . . . [select: Use_Replenishment_Ship's_Riggings_As_Range

. . . . Use_Replenishment_Ship's_Bulkheads_As_Range

. . . . Observe_Angle_Of_Phone_And_Distance_Line]

. . . goal: Make_Necessary_Correction ...to stay on station

. . . . [select goal: Turn_Ship

. . . . goal: Change_Speed_Of_Ship]

. . . goal: Inform_Helmsman_Before_Lines_Are_Tensioned

. . . . Receive_Report_That_Lines_Are_Being_Tensioned

. . . . . goal: Inform_Helmsman_To_That_Lines_Are_Being_Tensioned

. . . . . [select goal: Receive_Repeat-back ...if received

. . . . . goal: Repeat_Order] ...if not received

After a few hours of receiving stores and fuel, the time comes to breakaway. This involves the crew breaking down rigs that were setup to facilitate passing fuel and stores between the ships. When all the lines between the ships are clear and the CO gives the okay, it is safe for own ship to breakaway.

. goal: Complete_Breakaway_Phase

. . goal: Maintain_Station_Alongside ...same loop as above

. . . goal: Monitor_Lateral_Separation

. . . . [select: Observe_Wake_Between_Ships

. . . . Visually_Estimate_Opening/Closing_Trend]

. . . goal: Monitor_Fore_And_Aft_Motion

. . . . [select: Use_Replenishment_Ship's_Riggings_As_Range

. . . . Use_Replenishment_Ship's_Bulkhead_As_Range]

. . . goal: Make_Necessary_Correction ...to move towards station

. . . . [select goal: Turn_Ship

. . . . goal: Change_Speed_Of_Ship]

. . . goal: Inform_Helmsman_Before_Lines_Are_De-tensioned

. . . . Receive_Report_That_Lines_Are_Being_De-tensioned

. . . . . goal: Inform_Helmsman_To_That_Lines_Are_Being_De-tensioned

. . . . . [select goal: Receive_ Repeat-back ...if received

. . . . . goal: Repeat_Order] ...if not received

. . goal: Determine_All_Lines_Clear

. . . [select: Visually_Verify_All_Lines_Clear

. . . Receive_Report_All_Lines_Clear]

. . goal: Receive_Breakaway_Order_From_CO

. . . Receive_Verbal_Order_From_CO

. . . goal: Acknowledge_Receiving_Order

. . . . Verbally_Repeat_Order_Received

The Conning Officer increases own ship's speed by five to ten knots to pull ahead of the replenishment ship. Traditionally, the ship breaking away plays a breakaway song at this point. As own ship starts to gain speed, the Conning Officer's primary concern is the stern of own ship hitting the replenishment ship. As during the approach, the venturi between the ships fluctuates causing a stronger suction to occur during the breakaway. The Conning Officer should use small course changes, of one or two degrees, to maneuver own ship away until its stern is clear of the replenishment ship's bow. After the stern has cleared the bow, the Conning Officer is free to change speed and course as required in route to the next ordered station. However, it is not a good idea to cross the bow of the replenishment ship during the breakaway.

. . goal: Breakaway ...start breakaway

. . . goal: Change_Speed_Of_Ship ...increase speed to pull away

. . . goal: Turn_Ship ...done in small increments until stern is clear

. . . goal: Monitor_Ship's_Turn ...until stern clear

. . . . Observe_Ship's_Stern_Does_Not_Move_Towards_Replenishment_Ship

. . . goal: Make_Necessary_Correction

. . . . [select goal: Turn_Ship ...see repeated methods

. . . . goal: Change_Speed_of_Ship] ...see repeated methods

. . . goal: Determine_Stern_Is_Clear

. . . . Observe_Stern_Clear_Of_Replenishment_Ship's_Bow

. . goal: Go_To_Next_Station_Or_Duties_Assigned

B. TASK ANALYSIS OF AN OFFICER OF THE DECK DURING UNREP

The tasks the Officer of the Deck (OOD) performs during an UNREP differ from ship to ship. In most cases, once the approach starts, the CO personally supervises the Conning Officer until the ship is safely alongside the replenishment ship. This allows the CO and Conning Officer to concentrate on driving the ship while the OOD does most of the supporting administrative duties associated with the watch, such as: monitoring third party shipping, supervising the bridge watch team, and managing communications. This analysis assumes that the OOD will primarily organize and manage the internal operations of the ship, as well as provide support to the CO and Conning Officer during the UNREP.

The analysis was broken into three levels, first the Unit-Task Level, second the Functional Level and third the Detailed Level (Argument Level). As the analysis progresses from the Unit-Task Level to the Detailed Level, more detail is captured in each successive level.

1. Unit Task Level Analysis

The Unit-Task indicates that the top-level goal was to execute an UNREP. How does the OOD fit into this Unit-Task? The OOD is responsible for coordinating the whole team. This means the OOD must know what everyone else is suppose to be doing and must ensure that they do their jobs effectively. The OOD is directly responsible to the CO for the operation and safety of the ship. The GOMS representation of the Unit-Task remains unchanged.

goal: Execute_UNREP

. goal: Complete_Brief_Phase

. goal: Complete_Approach_Phase

. goal: Complete_Alongside_Phase

. goal: Complete_Breakaway_Phase

2. Functional Level Analysis

The Functional Level was developed by decomposing the tasks the OOD would typically have to accomplish during an UNREP. Most of the OOD's tasks closely parallel the tasks the Conning Officer must accomplish with more of an emphasis on supervision.

goal: Execute_UNREP

. goal: Complete_Brief_Phase

. . goal: Know_UNREP_Plan

. goal: Complete_Approach_Phase

. . goal: Know_UNREP_Plan

. . goal: Supervise_Bridge_Watch_Team

. . goal: Maintain_Communications

. . goal: Ensure_Safety_Of_Own_Ship

. . goal: Maintain_Awareness_Of_Third_Party_Ships

. . goal: Ensure_Own_Ship_Ready_To_Go_Alongside

. . goal: Ensure_Conning_Officer_Maintains_Station

. . goal: Supervise_Conning_Officer_During_Approach

. goal: Complete_Alongside_Phase

. . goal: Supervise_Conning_Officer_While_Alongside

. . goal: Determine_When_Bow_Crosses_Stern

. . goal: Watch_For_Bow_To_Be_Pushed_Away_From_Replenishment_Ship

. . goal: Monitor_Venturi_Effect_Alongside_Replenishment_Ship

. . goal: Determine_Lateral_Separation

. . goal: Determine_Range_To_Station_Closing_Rate

. . goal: Determine_When_To_Match_Speed

. . goal: Maneuver_Close_To_Station_Alongside

. . goal: Get_Phone_And_Distance_Line_Across

. . goal: Maintain_Station_Alongside ...loop until UNREP complete

. . goal: Supervise_Bridge_Watch_Team

. . goal: Maintain_Awareness_Of_Third_Party_Shipping

. . goal: Maintain_Communications

. goal: Complete_Breakaway_Phase

. . goal: Supervise_Conning_Office _While_Alongside

. . goal: Supervise_Bridge_Watch_Team

. . goal: Maintain_Awarness_Of_Third_Party_Shipping

. . goal: Know_Where_To_Go_Next

. . goal: Maintain_Communications

3. Detailed Level Analysis

As before, the Detailed Level analysis was created by further decomposing the tasks outlined in the Functional Level analysis. Throughout the analysis, remember that the OOD may choose to select one of several methods to accomplish a goal. Some tasks may be repeated often while others may loop several times to show that the task is done frequently to monitor the progress towards achieving a goal. The sequence of the goals presented in the analysis will vary from UNREP to UNREP as well as from OOD to OOD.

The OOD attends the same briefs and records the same information as the Conning Officer. Since the OOD is in charge of the bridge watch team, it is equally important for the OOD to know the UNREP plan and engineering plant status as it is for the Conning Officer. The OOD is typically senior to the Conning Officer and has more influence in formulating the UNREP plan. The OOD and CO will discuss the UNREP plan in detail during the brief. The Unit-Task remains unchanged.

goal: Execute_UNREP

. goal: Complete_Brief_Phase

. . goal: Know_UNREP_Plan

. . . [select: Go_To_OPS_Brief

. . . Go_To_CIC_Before_Watch

. . . Receive_UNREP_Brief_on_Bridge

. . . Talk_To_Operations_Officer_About_Changes

. . . Talk_To_CO_About_Plan]

. . . goal: Know_Plant_Configuration

. . . . [select: Go_To_OPS_Brief

. . . . Go_To_CCS_Before_Watch

. . . . Receive_UNREP_Brief_on_Bridge

. . . . Talk_To_Chief_Engineer_About_Plant_Status]

Once on the bridge, it is the OOD's duty to coordinate the preparation necessary to conduct an UNREP. Personnel must be on station throughout the ship and numerous

communication circuits must be established and checked before the ship is ready to UNREP. A checklist is kept on the bridge to aid in keeping track of all the tasks that must be accomplished throughout the ship before it goes alongside. As crewmembers complete tasks, they call the bridge to report that they have accomplished a required task. The OOD then records that the task has been completed. By reviewing the checklist periodically, the OOD can determine what remains to be done. If required, the OOD can contact the department responsible for a task on the checklist to expedite its completion. The OOD is the center of the operation. The OOD must know the big picture as well as who is responsible for the little details. If something is not right and the OOD can not fix the problem, the OOD must know who to contact to get the problem solved immediately. To become an excellent OOD takes years of experience beyond initial qualification.

The OOD plays a major part in getting the ship positioned astern the replenishment ship and up to this point the OOD and Conning Officer act as a team. The OOD monitors the Conning Officer's actions and makes necessary corrections to ensure the safety of own ship. However, from the start of the approach and until the UNREP is complete, the CO and Conning Officer go to the bridge wing and work together to maneuver the ship alongside and on a parallel course with the replenishment ship. The OOD provides support by organizing the bridge watch team to ensure none of the supporting tasks, i.e. communications, are missed or delayed.

. goal: Complete_Approach_Phase

. . goal: Know_UNREP_Plan

. . . [select: Receive_UNREP_Brief_On_Bridge

. . . Talk_To_Operations_Officer_About_Changes

. . . Talk_To_CO_About_Plan]

. . . goal: Know_Plant_Configuration

. . . . [select: Call_CCS_From_Bridge

. . . . Ask_Lee_Helm_To_Get_Configuration_From_CCS

. . . . Talk_To_Chief_Engineer_About_Plant_Status]

. . . goal: Determine_Side_To_Approach_On

. . . . [select: Observe_ROMEO_Flag_On_Replenishment_Ship

. . . . Radio_Communication_With_Replenishment_Ship]

Supervising the bridge watch team involves ensuring each team member is equipped to do their job and is doing what they are suppose to be doing. To keep watch standers well rested and alert, they are rotated several times during an UNREP. This includes the Conning Officer's position, which is frequently rotated to provide an opportunity for more than one officer to drive. The OOD must monitor personnel and coordinate watch relief. Additionally, the OOD is responsible for executing the ship's communications plan, which include monitoring several phone and radio channels simultaneously.

. . goal: Supervise_Bridge_Watch_Team

. . . goal: Ensure_Bridge_Manned_Ready ...before starting approach

. . . . Observe_Each_Station_Manned

. . . . . goal: Correct_Discrepancies ...if not manned

. . . . . Contact_Responsible_Department

Each of the UNREP stations, phone and distance line station, Central Control Station, Aft Steering, and Combat Information Center has manned phone circuits directly to the bridge. This provides immediate access to information in both directions. The phone talkers who man these circuits relay all reports to the OOD. The OOD also must monitor several radios used to communicate with other ships in the group. Flag hoists, flashing light signals, and semaphore signals are other methods used to pass messages between ships at sea. All incoming and outgoing messages should be reviewed by the OOD.

. . . goal: Ensure_All_Communications_Equipment_Operational

. . . . Order_All_Watch_Standers_To_Do_Phone_Check

. . . . . goal: Correct_Discrepancies ...if not operational

. . . . . Contact_Responsible_Department

. . . goal: Ensure_Signalman_Has_Correct_Flags_Displayed

. . . . Observe_Flags_From_Bridge_Wing

. . . . . goal: Correct_Discrepancies ...if not correct

. . . . . Contact_Signalman

During an UNREP, own ship will display the ball diamond ball day shapes and at night or in low visibility three red lights on its mast to inform all third party shipping that it is restricted in its maneuverability [CHIE96]. At night, as well as in low visibility, other

running lights will be illuminated to provide increased visibility. Running lights and day shapes enable distant ships to determine who has the right of way and in which direction a vessel is headed. The OOD must ensure the correct lights and day shapes are displayed.

. . . goal: Ensure_Quartermaster_Has_Correct_Lights_Displayed

. . . . Observe_Masthead_Lights_From_Bridge_Wing

. . . . . goal: Correct_Discrepancies ...if not correct

. . . . . Contact_Quartermaster

Normally, an electronics technician is available on the bridge to make quick repairs or assist in the setup of radar and communications equipment. The OOD and Conning Officer are required to know what each piece of equipment does and where it is located on the bridge.

. . . goal: Ensure_All_Bridge_Equipment_Setup_And_Operational

. . . . Check_Radar_Display

. . . . Check_Radios

. . . . Check_Miscellaneous_Equipment

. . . . . goal: Correct_Discrepancies ...if not operational

. . . . . Contact_Problem

. . . goal: Ensure_Bridge_Watch_Standers_Remain_Alert

. . . . Monitor_Behavior_Of_Watch_Standers

. . . . Control_Noise_Level_On_Bridge

. . . . . goal: Correct_Discrepancies ...if not alert

. . . . . Contact_Problem

. . goal: Maintain_Communications ...with CO, Conn, Helm and Lee helm

. . . [select goal: Communicate_With_Watch_Team

. . . . . [select: Yell_Through_Hatch

. . . . Visual_Expression

. . . . Verbal_Communications]

. . . goal: Communicate_With_Other_Ships

. . . . [select: Use_Bridge_To_Bridge_Radio

. . . . Use_Secure_Radio

. . . . Use_Flag_Signals

. . . . Use_Flashing_Light_Signals]

. . . Verify_Message_Received]

As each station becomes manned and phone communications are established, manned and ready reports are sent to the bridge where they are recorded. Once all stations report manned and ready and restricted maneuvering is set, the ship is ready to make its approach. Flag ROMEO is hoisted to the dip to indicate the ship is ready to make its approach. At this time the Conning Officer should see ROMEO at the dip on the replenishment ship.

. . goal: Ensure_Own_Ship_Ready_To_Go_Alongside

. . . Monitor_UNREP_Checklist

. . . goal: Ensure_All_Personnel_On_Station

. . . . Receive_Manned_Ready_Reports_From_UNREP_Stations

. . . . Receive_Manned_Ready_Reports_From_All_Department_Heads

. . . . goal: Contact_Department_Head_Of_Delinquent_Department

. . . . . Call_Department_Head

. . . goal: Set_Restricted_Maneuvering

. . . . goal: Get_Permission_To_Set_Restricted_Maneuvering_From_CO

. . . . goal: Pass_The_Word_That_Restricted_Maneuvering_Is_Set

. . . . . Announce_That_Restricted_Maneuvering_Is_Set

. . . goal: Inform_CO_Ship_Is_Manned_Ready_To_Go_Alongside

. . . . Make_Verbal_Report_To_CO

. . . goal: Raise_ROMEO_On_The_Side_To_Go_Alongside

. . . . Order_Signalman_To_Close-up_ROMEO

The OOD must frequently visually scan the horizon for new contacts and monitor contacts that have already been reported. Additionally, the OOD will use the radar display to detect and track contacts. The OOD will report only those contacts that are predicted to close within a range specified by the CO, typically around ten thousand yards. Ships closing within five thousand yards may be hailed on the bridge to bridge radio to determine its intentions.

. . goal: Maintain_Awareness_Of_Third _Party_Ships ...done frequently

. . . [select: Visually_Scan_Horizon

. . . Observe_Radar_Display

. . . Communicate_With_Ship's_Combat_Information_Center

. . . Receive_Contact_Reports]

. . goal: Ensure_Safety_Of_Own_Ship

. . . Monitor_Third_Party_Shipping

. . . Make_Contact_Reports_To_CO

. . . Observe_Everything_In_Sight_And_Sound

Unless the CO is supervising the Conning Officer, the OOD should monitor the Conning Officer's actions. An experienced OOD can be a tremendous aid to a relatively inexperienced Conning Officer by providing helpful tips that prevent embarrassing zigzag maneuvers on the way to station. The OOD's main concern is the safety of own ship, specifically, not hitting anything. A secondary concern is the ship's reputation. If a Conning Officer can not precisely maintain a station or is unable to make very smart, military, and efficient maneuvers to get to station, the ship will earn a bad reputation for the CO.

. . goal: Ensure_Conning_Officer_Maintains_Station

. . . goal: Get_Bearing_And_Range_To_Replenishment_Ship

. . . . [select goal: Get_Bearing_To_Replenishment_Ship

. . . . . [select: Request_Bearing_From_Conning_Officer

. . . . . Use_Alidade_On_Bridge_Wing

. . . . . Replenishment_Ship's_Masts_Lineup

. . . . . Observe_Radar_Display

. . . . . Masthead_Lights_Of_Replenishment_Ship_Lineup

. . . . . Own_Ship_In_Wake_Of_UNREP_Ship]

. . . . goal: Get_Range_To_Replenishment_Ship

. . . . . [select: Request_Range_From_Conning_Officer

. . . . . Get_Range_From_Stadimeter

. . . . . Call_For_Radar_Range

. . . . . Visual_Estimate]

. . . Verify_On_Station]

In order to monitor the Conning Officer, the OOD must compare the actual range and bearing to the replenishment ship with the ordered range and bearing, as well as consider if the Conning Officer is taking action to correct discrepancies in a timely fashion. Essentially, the OOD must detect and monitor the same visual and audible cues as the Conning Officer in order to ensure the correct actions are being taken. If the OOD determines the Conning Officer is not taking the correct actions, the OOD should provide help by giving suggestions or giving specific orders to the Conning Officer. In the rare case when a Conning Officer is unable to drive the ship even with the OOD's help, or in an emergency, the OOD may take the conn from the Conning Officer and drive the ship until a new Conning Officer is assigned.

. . . goal: Determine_If_Conning_Officer_Is_Conning_Safely

. . . . Compare_Current_Range_&_Bearing_To_Ordered_Range_&_Bearing

. . . . goal: Correct_Conning_Officer_As_Necessary

. . . . . [select goal: Coach_Conning_Officer

. . . . . . Make_Helpful_Course_Speed_Recommendations

. . . . . goal: Order_Conning_Officer_To_Correct_Problem

. . . . . . Give_Conning_Officer_Engine_Orders

. . . . . . Give_Conning_Officer_Rudder_Orders]

. . goal: Supervise_Conning_Officer_During_Approach ...CO does this

. . . goal: Observe_ROMEO_Close-up_On_Replenishment_Ship

. . . . [select: Observe_ROMEO_On_The_Side_Own_Ship_Will_Approach

. . . . Observe_Flashing_Light_Signal ...at night/low visibility

. . . . Receive_Radio_Transmission] ...at night/low visibility

. . . goal: Receive_Approach_Order_From_CO

. . . . [select: Receive_Verbal_Order_From_CO_To_Commence_Approach

. . . . Receive_Verbal_Order_Via_XO_To_Commence_Approach]

. . . . goal: Acknowledge_Receiving_Order

. . . . . Verbally_Repeat_Order_Received

. . . goal: Order_Conning_Officer_To_Commence_Approach

. . . . Verbally_Order_Conning_Officer

. . . goal: Monitor_Ship's_Turn ...may use multiple methods

. . . . [select: Observe_Rudder_Angle_Indicator

. . . . Observe_Feeling_Ship_Heel

. . . . Observe_Wake_Of_Own_Ship

. . . . Observe_Horizon

. . . . Observe_Gyrocompass_Heading_Change

. . . . Observe_Feeling_That_Ship_ Is_Turning

. . . . Observe_Rate_Of_Turn_Increase/Decrease]

. . . . goal: Monitor_Helm

. . . . . Observe_Turn_Progress_On_Gyrocompass

. . . . . Observe_Rudder_ Angle_Indicator

. . . goal: Monitor_Conning_Officer_During_Maneuver

. . . . goal: Correct_Conning_Officer_As_Necessary

. . . goal: Determine_Range_To_Replenishment_Ship

. . . . [select: Get_Range_From_Stadimeter

. . . . Call_For_Radar_Range]

. . . goal: Determine_Range_Closing/Opening_Rate

. . . . [select: Call_For_Current_Speed

. . . . Observe_Speed_Indicator

. . . . Estimate_Closing_Rate]

. . . goal: Determine_Lateral_Separation_Closing/Opening

. . . . goal: Shoot_Bearing_To_Replenishment_Ship

. . . . . [select: Use_Alidade_On_Bridge_Wing

. . . . . Call_For_Radar_Bearing] ...at night/low vis

. . . . goal: Determine_If_Lateral_Separation_Too_Close/Far

. . . . . [select: Use_Radian_Rule_Method

. . . . . Use_Table_Of_Radian_Rule_Values_Method

. . . . . Observe_Distance_Between_Wakes

. . . . . Use_Seaman's_Eye_Method ...requires experience

. . . . . Use_Combination_Of_The_Above]

. . . goal: Monitor_Conning_Officer_During_Maneuver

. . . . goal: Correct_Conning_Officer_As_Necessary

In the unlikely event that the CO is not supervising the Conning Officer at the point of the approach when the bow is about to cross the stern, the OOD should closely monitor own ship's position relative to the replenishment ship and take action as required to ensure that there is not a collision. For example, if the OOD thinks own ship is too close and the Conning Officer is continuing the approach, the OOD must give the Conning Officer instructions to slow or turn away to prevent an accident.

. . . goal: Monitor_Bow_As_It_Approaches_Replenishment_Ship's_Stern

. . . . Watch_For_Pressure_To_Push_Bow_Away_From_Stern

. . . goal: Determine_If_Lateral_Separation_Is_Safe_To_Go_Alongside

. . . . Visually_Estimate_Lateral_Separation

. . . goal: Monitor_Conning_Officer_During_Maneuver

. . . . Determine_If_Order_From_Conning_Officer_Correct_For_Situation

. . . . goal: Correct_Conning_Officer_As_Necessary

. . . . . [select goal: Coach_Conning_Officer

. . . . . . Make_Helpful_Course_Speed_Recommendations

. . . . . goal: Order_Conning_Officer_To_Correct_Problem

. . . . . . Give_Conning_Officer_Engine_Orders

. . . . . . Give_Conning_Officer_Rudder_Orders]

Once alongside, the OOD must continue to closely monitor the Conning Officer until own ship has settled into station and the phone and distance line is across. The alongside phase is a good officer training opportunity and usually many officers are allowed to drive the ship. Some COs may enjoy personally instructing the junior officers as they take their turns conning and others may want to observe the XO or let the OOD train the officers, so the OOD's role can vary.

. goal: Complete_Alongside_Phase

. . goal: Supervise_Conning_Officer_While_Alongside ...CO does this

. . . goal: Monitor_Conning_Officer_During_Maneuver

. . . . Determine_If_Order_From_Conning_Officer_Correct_For_Situation

. . . . goal: Correct_Conning_Officer_As_Necessary

. . . . . [select goal: Coach_Conning_Officer

. . . . . . Make_Helpful_Course_Speed_Recommendations

. . . . . goal: Order_Conning_Officer_To_Correct_Problem

. . . . . . Give_Conning_Officer_Engine_Orders

. . . . . . Give_Conning_Officer_Rudder_Orders]

. . goal: Supervise_Bridge_Watch_Team

. . . goal: Ensure_All_Personnel_Are_Alert

. . . . Observe_Bridge_Watch_Standers

. . . goal: Ensure_All_Equipment_Failures_Are_Immediately_Corrected

. . . . Immediately_Contact_Responsible_Department

. . . goal: Ensure_Quartermaster_Maintains_Correct_Track

. . . . [select: Observe_Ship's_Track_On_Chart

. . . . Discuss_Ship's_Track_With_Quartermaster]

. . . goal: Maintain_Quiet_Bridge

. . . . Monitor_Conversation_And_Noise_Level_On_Bridge

. . goal: Determine_When_Bow_Crosses_Stern

. . . Visually_Estimate

. . goal: Watch_For_Bow_To_Be_Pushed_Away_From_Replenishment_Ship

. . . Observe_Bow_Motion

. . goal: Monitor_Venturi_Effect_Alongside_Replenishment_Ship ...< 80 feet

. . . Observe_Wake_Action_Between_Ships

. . . goal: Monitor_Lateral_Separation_Distance

. . . . Visually_Estimate_Opening/Closing_Trend ...depth perception

. . . . Visually_Estimate_Lateral_Separation ...depth perception

. . . goal: Monitor_Conning_Officer_During_Maneuver

. . . . goal: Correct_Conning_Officer_As_Necessary

. . goal: Determine_Lateral_Separation ...>80 feet

. . . [select: Observe_Wake_Action_Between_Ships

. . . Visually_Estimate_Lateral_Separation_Distance]

. . . goal: Monitor_Conning_Officer_During_Maneuver

. . . . goal: Correct_Conning_Officer_As_Necessary

. . goal: Determine_Range_To_Station_Closing_Rate

. . . goal: Determine_Range_To_Station

. . . . [select: Visually_Estimate_Distance

. . . . Observe_Rate_At_Which_Items_On_Replenishment_Ship_Pass]

. . . goal: Monitor_Conning_Officer_During_Maneuver

. . . . goal: Correct_Conning_Officer_As_Necessary

. . goal: Determine_When_To_Match_Speed

. . . Compare_Relative_Speed_Of_Ships_Estimate_When_To_Match_Speed

. . . . goal: Change_Speed_of_Ship

. . goal: Maneuver_Close_To_Station_Alongside

. . . goal: Monitor_Ships_Heading_On_Gyrocompass

. . . . Observe_Bridge_Wing_Gyrocompass

. . . goal: Monitor_Lateral_Separation

. . . . Observe_Wake_Between_Ships

. . . . Visually_Estimate_Opening/Closing_Trend

. . . goal: Monitor_Fore_And_Aft_Motion

. . . . [select: Use_Replenishment_Ship's_Riggings_As_Range

. . . . Use_Replenishment_Ship's_Bulkhead_As_Range]

. . . goal: Monitor_Conning_Officer_During_Maneuver

. . . . goal: Correct_Conning_Officer_As_Necessary

. . goal: Get_Phone_And_Distance_Line_Across ...when on station

. . . Give_Order_To_Send_Phone_And_Distance_Line_Across

. . goal: Maintain_Station_Alongside ...loop until UNREP complete

. . . goal: Monitor_Lateral_Separation

. . . . [select: Observe_Flags_On_Phone_And_Distance_Line

. . . . Visually_Estimate_Opening/Closing_Trend

. . . . Observe_Chemical_Lights_On_Phone_And_Distance_Line]

. . . goal: Monitor_Fore_And_Aft_Motion

. . . . [select: Use_Replenishment_Ship's_Riggings_As_Range

. . . . Use_Replenishment_Ship's_Bulkheads_As_Range

. . . . Observe_Angle_Of_Phone_And_Distance_Line]

. . . goal: Monitor_Conning_Officer_During_Maneuver

. . . . goal: Correct_Conning_Officer_As_Necessary

. . . goal: Determine_Where_Own_Ship_Will_Go_After_UNREP

. . . . Discuss_Plans_With_Operations_Officer

. . . . Discuss_Plans_With_Combat_Information_Center_Watch_Officer

. . . . Discuss_Plans_With_CO

. . . goal: Monitor_Progress_Of_Stores_And_Fuel_Transfer

. . . . Receive_Progress_Reports_Form_UNREP_Stations

. . . . goal: Report_Progress_To_CO

. . . . . Make_Verbal_Report_To_CO

Own ship remains stationed alongside until all lines are clear and the CO gives the okay to breakaway. During the breakaway, it is important that the OOD know where the ship is headed next. Usually, if own ship is in a formation with the replenishment ship as the guide, own ship will receive a tactical command to take a new station relative to the guide. On the other hand, if own ship meets with the replenishment ship solely for UNREP purposes, own ship will likely be released to continue on duties assigned.

. goal: Complete_Breakaway_Phase

. . goal: Maintain_Station_Alongside

. . goal: Determine_All_Lines_Clear

. . . [select: Visually_Verify_All_Lines_Clear

. . . Receive_Report_All_Lines_Clear]

. . goal: Receive_Breakaway_Order_From_CO

. . . Receive_Verbal_Order_From_CO

. . . goal: Acknowledge_Receiving_Order

. . . . Verbally_Repeat_Order_Received

. . goal: Breakaway

. . . goal: Ensure_Conning_Officer_Commences_Breakaway_Maneuver

. . . . Observe_Conning_Officers_Actions

. . . goal: Monitor_Turn

. . . . Observe_Ship's_Stern_Doesn't_Move_Towards_Replenishment_ Ship

. . . goal: Monitor_Conning_Officer_During_Maneuver

. . . . Determine_If_Order_From_Conning_Officer_Correct_For_Situation

. . . . goal: Correct_Conning_Officer_As_Necessary

. . . . . [select goal: Coach_Conning_Officer

. . . . . . Make_Helpful_Recommendations

. . . . . goal: Order_Conning_Officer_To_Correct_Problem

. . . . . Give_Conning_Officer_Engine_Orders

. . . . . Give_Conning_Officer_Rudder_Orders]

The OOD's, as well as the Conning Officer's, primary concern during the breakaway is that own ship's stern will clear the replenishment ship's bow. The OOD should monitor the stern as the Conning Officer increases own ship's speed and gives slight, one or two degree, course changes until the stern is clear. After the stern is clear, own ship will head towards its new station, if given, or proceed on duties assigned.

. . . goal: Determine_Stern_Is_Clear

. . . . Observe_Stern_Clear_Of_Replenishment_Ship's_Bow

. . goal: Go_To_Next_Station_Or_Duties_Assigned

C. TASK ANALYSIS OF A HELMSMAN DURING UNREP

The tasks a Helmsman must perform during an UNREP are presented below to show the teamwork involved in conducting an UNREP, specifically the ship-handling element of an UNREP. Since the Helmsman's tasks are intentionally very specific and kept to a minimum, analyzing the Helmsman was much simpler than analyzing the Conning Officer. The Helmsman's tasks are relatively easy to distinguish and are routinely repeated. An inexperienced observer could watch a Helmsman at work for a short period of time, say fifteen minutes, and make a reasonable analysis of the tasks the Helmsman must perform. The same is not true for the Conning Officer or the OOD.

The analysis was broken into three levels, first the Unit-Task Level, second the Functional Level and third the Detailed Level (Argument Level). As the analysis progresses from the Unit-Task Level to the Detailed Level, more detail is captured in each succeeding level.

1. Unit Task Level Analysis

The Unit-Task indicates that the top-level goal was to execute an UNREP. How does the Helmsman fit into this Unit-Task? Would not the Helmsman's Unit-Task be better stated as Steer_Ship? Yes, however, the primary goal of the team is to execute an UNREP and the Helmsman plays a significant role in accomplishing this task. Thus the Unit-Task remains Execute_UNREP. The Steer_Ship task appears later in the Functional Level analysis. The GOMS representation of the Unit-Task remained unchanged.

goal: Execute_UNREP

. goal: Complete_Approach_Phase

. goal: Complete_Alongside_Phase

. goal: Complete_Breakaway_Phase

2. Functional Level Analysis

The Functional Level analysis showed that during all phases of an UNREP the Helmsman's goal was to steer the ship as ordered. The Functional Level GOMS notation follows:

goal: Execute_UNREP

. goal: Complete_Approach_Phase

. . goal: Maintain_Ordered_Course

. . goal: Turn_Ship_As_Ordered

. goal: Complete_Alongside_Phase

. . goal: Maintain_Ordered_Course

. . goal: Turn_Ship_ As_Ordered

. goal: Complete_Breakaway_Phase

. . goal: Maintain_Ordered_Course

. . goal: Turn_Ship_As_Ordered

3. Detailed Level Analysis

During the Detailed Level analysis, the Steer_Ship goal was broken into its subtasks and methods. The Helmsman must accomplish the subtasks and methods detailed below to satisfactorily steer the ship.

goal: Execute_UNREP

The sequence of events the Helmsman performs during the approach is quite limited when compared to that of the Conning Officer. The Helmsman would likely receive numerous orders to turn the ship while the Conning Officer attempts to maintain station astern of the replenishment ship. When given a course to steer, the Helmsman is free to use the steering wheel to control the rudder in order to maintain the ordered course. Generally, there are limits placed on how much rudder the Helmsman can use without first getting permission from the Conning Officer. For example, in most cases, no more than ten degrees rudder in either direction is allowed without first requesting permission from the Conning Officer. The primary reason the Helmsman would need to use more than ten degrees rudder to maintain a course is a high sea-state. In this case, the Helmsman requests permission to use more than ten degrees rudder to maintain course. The Conning Officer would likely grant permission, and then the Helmsman would be free to use the rudder as required.

. goal: Complete_Approach_Phase

. . goal: Maintain_Ordered_Course ...normal condition loop

. . . Observe_Changes_In_Gyrocompass_Heading

. . . goal: Steer_To_Maintain_Ordered_Course

. . . . Turn_Wheel_As_Required_To_Maintain_Course ...within limits

At some point, soon after the Conning Officer decides to commence the approach, a turn order will be verbally given to the Helmsman. The alert Helmsman would receive the order, repeat it back, and turn the wheel in the ordered direction the ordered number of degrees. The Helmsman will report to the Conning Officer when the rudder is over the ordered amount. Note that the Conning Officer should monitor the Helmsman by observing the Rudder Angle Indicator and Gyrocompass Repeater on the bridge wing. If the order included a course to steady on, the Helmsman will initially turn the rudder the ordered amount. However, as the ship approached the ordered course, the Helmsman should automatically reduce the rudder and counter steer as required to stop the swing of the ship on the ordered course without over shooting. The other scenario would be that no course was given with the initial order. For example, "Right Full Rudder" in this case the Helmsman must put the rudder over right full, do the required reports, and wait for the Conning Officer to order a course. When a course is ordered, the Helmsman would follow the same process stated previously to stop the ship on the ordered course.

. . goal: Turn_Ship_As_Ordered

. . . goal: Receive_Order_From_Conning_Officer

. . . . Listen_For_Order

. . . . goal: Repeat_Order_Back_To_Conning_Officer

. . . . . goal: Receive_Acknowledgement

. . . goal: Turn_Wheel

. . . . Turn_Wheel_In_Ordered_Direction_The_Ordered_Amount

. . . . goal: Report _That_The_Wheel_Is_Over_To_The_Conning_Officer

. . . . . goal: Receive_Acknowledgement

For the Helmsman to quickly steady the ship on a course without zigzagging takes a great deal of experience. Essentially, the Helmsman must monitor the gyrocompass and rudder angle indicator constantly throughout the turn. The gyrocompass helps the Helmsman determine the rate at which the ship is turning, enabling the Helmsman to estimate when to decrease the rudder and/or counter steer.

. . . goal: Monitor_Turn

. . . . [select: Observe_Changes_In_Gyrocompass_Heading

. . . . Observe_Rate_Of_Ships_Turn

. . . . Observe_Rudder_Angle_Indicator

. . . . Observe_Feel_Of_Ship_Turn

. . . . Observe_Horizon]

. . . goal: Stop_Ships_Turn_On_Ordered_Course

. . . . Estimate_When_To_Reduce_Degree_Of_Rudder

. . . . goal: Reduce_Rudder_To_Slow_Swing_Of_Ship

. . . . . Turn_Wheel_As_Required

. . . . goal: Stop_The_Swing_Of_The_Ship

. . . . . Estimate_Degree_Of_Counter_Rudder_To_Stop_Swing_Of_Ship

. . . . . goal: Counter_Steer_To_Stop_Swing_Of_Ship

. . . . . Turn_Wheel_As_Required_In_Opposite_Direction_Of_Turn

. . . . goal: Steady_Ship_On_Ordered_Course

. . . . . Make_Small_Steering_Corrections_Until_Ship_Is_Steady_On_Course

. . . . goal: Report_Ship_Steady_On_Ordered_Course_To_Conning_Officer

Since the Conning Officer is able to see the Ship's Control Console and associated alarms from the bridge wing, the Helmsman must know the immediate actions to take in the event of a steering equipment casualty. A steering equipment casualty is one of the most dangerous casualties that can occur during a UNREP. One of several events should alert the Helmsman that a steering casualty has occurred; the rudder angle indicator does not move in the direction the rudder was turned or a steering cable or motor alarm goes off. Steering casualties are discussed in detail in Chapter Four.

. . . goal: Inform_Conning_Officer_Of_Steering_Problems

. . . . goal: Detect_Steering_System_Casualty

. . . . . [select: Observe_Steering_Alarms

. . . . Notice_No/Slow_Response_To_Turn_Of_Wheel

. . . . Receive_Steering_Casualty_Message_From_Aft_Steering

. . . . Notice_Loss_Of_Gyrocompass]

As previously explained, the Helmsman alerts the Conning Officer of difficulties maintaining course by requesting permission to use greater than ten degrees rudder to maintain course.

. . . . goal: Detect_Steering_Problems_Related_To_Sea_Condition

. . . . . Notice_Need_To_Use_More_Rudder_Than_Normally_Required

. . . . . goal: Get_Permission_From_Conning_Officer_To_Use_More_Rudder

The Helmsman must be alert and standing by to receive orders at all times. All other communications with the Helmsman are minimized. However, in case of emergency, the Helmsman must maintain communications with aft steering over a phone circuit. This procedure allows aft steering to communicate with the bridge and receive rudder orders in the event of a steering casualty.

. . . goal: Maintain_Communications ...with Conning Officer

. . . . [select: Use_Amplified_Communications_System

. . . Use_Someone_To_Relay] ...if amp fail/not available

. . . . Verify_Communications_Received

The subtasks and method associated with the Complete_Alongside_Phase as well as the Complete_Breakaway_Phase are, with few exceptions, identical to those discussed for the Complete_ Appraoch_ Phase. The only exceptions are that during the Complete_ Alongside _Phase, the Helmsman must be particularly diligent when monitoring the ship's heading to ensure it does not stray off course and while trying to maintain ordered course, the Helmsman must use precise rudder control. While alongside, there is very little room for error.

D. TASK ANALYSIS OF A LEE HELMSMAN DURING UNREP

The tasks a Lee Helmsman must perform during an UNREP are presented below to show the teamwork involved in conducting an UNREP, specifically the ship-handling element of an UNREP. Since the Lee Helmsman's tasks are intentionally very specific and kept to a minimum, analyzing the Lee Helmsman was as straightforward as the analysis of the Helmsman. The Lee Helmsman's tasks are relatively easy to distinguish and routinely repeated. As with the Helmsman, an inexperienced observer could watch a Lee Helmsman at work for a short period of time and make a reasonable analysis of the tasks that must be performed.

Again, the analysis was broken into three levels, first the Unit-Task Level, second the Functional Level and third the Detailed Level (Argument Level). As the analysis progresses from the Unit-Task Level to the Detailed Level, more detail is captured in each succeeding level.

1. Unit Task Level Analysis

The Unit-Task remains unchanged to maintain the same frame of reference throughout the analysis of each team member.

goal: Execute_UNREP

. goal: Complete_Approach_Phase

. goal: Complete_Alongside_Phase

. goal: Complete_Breakaway_Phase

2. Functional Level Analysis

The Functional Level analysis showed that during all phases of an UNREP the Lee Helmsman's goal was to change the ship's speed as ordered. The Functional Level GOMS notation follows:

goal: Execute_UNREP

. goal: Complete_Approach_Phase

. . goal: Maintain_Ordered_Speed

. . goal: Change_Speed_As_Ordered

.

. goal: Complete_Alongside_Phase

. . goal: Maintain_Ordered_Speed

. . goal: Change_Speed_As_Ordered

. goal: Complete_Breakaway_Phase

. . goal: Maintain_Ordered_Speed

. . goal: Change_Speed_As_Ordered

3. Detailed Level Analysis

During the Detailed Level analysis, the Maintain_Ordered_Speed goal was broken into its subtasks and methods. The Lee Helmsman must accomplish the subtasks and methods detailed below to satisfactorily change the ship's speed.

goal: Execute_UNREP

The tasks required to maintain ordered speed are identical during the Complete_ Approach_Phase, Complete_Alongside_Phase, and Complete_Breakaway_Phase, therefore, the detailed analysis is presented only once. As with the Helmsman, the only difference for the Lee Helmsman is that while alongside, increased attention to detail and precision is required.

The Lee Helmsman controls the ship's throttles at the Ship's Control Console during UNREP on the bridge. The Lee Helmsman must maintain control of the throttles, remain alert to receive orders, change the throttle position when ordered, and maintain communications with the Central Control Station (CCS). Throughout the UNREP the Conning Officer will likely make many speed changes. For the Lee Helmsman, the GOMS notation is straightforward.

. goal: Complete_Approach_Phase

. . goal: Maintain_Ordered_Speed ...normal condition loop

. . . [select: Observe_Throttle ...ensure it is not moved

. . . Observe_RPM_Indicator

. . . Observe_Pitch_Indicator

. . . Observe_Speed_Indicator]

. . goal: Change_Speed_As_Ordered

. . . goal: Receive_Engine_Order

. . . . Listen_For_Order_From_Conning_Officer

. . . . goal: Repeat_Order_Back_To_Conning_Officer

. . . goal: Change_Throttle_To_Ordered_Speed

. . . . [select: Change_Throttle_To_Match_RPM_Of_Ordered_Speed

. . . Change_Throttle_To_Match_Pitch_Of_Ordered_Speed]

. . . goal: Report_Pitch/RPM_Change_Complete_To_Conning_Officer

The Lee Helmsman should continuously monitor the RPM indicators for both shafts, and the ship's speed indicator for abnormal fluctuations. Any abnormal conditions should be immediately reported to the Conning Officer. Since the Lee Helmsman maintains a communication circuit with CCS, it is likely that the Lee Helmsman will be the first person on the bridge to know when an engineering casualty occurs. The Lee Helmsman may alert the OOD that a casualty has occurred, but all such reports should be verified by contacting the Engineering Officer of the Watch in CCS before any action is taken.

. . . goal: Inform_Conning_Officer_Of_Engineering_Problems

. . . . goal: Detect_Unusual_Changes_In_RPM

. . . . . Observe_RPM_Indicator

. . . . . Report_Problem_To_Conning_Officer

. . . . goal: Detect_Unusual_Changes_In_Pitch

. . . . . Observe_Pitch_Indicator

. . . . . Report_Problem_To_Conning_Officer

. . . . goal: Detect_No/Slow_Response_To_Throttle_Changes

. . . . . Report_Problem_To_Conning_Officer

. . . goal: Maintain_Communications ...with CCS, Aft Steering,

. . . . [select: Use_Amplified_Communications_System

. . . Use_Someone_To_Relay]

. . . . Verify_Order_Received

E. ANALYSIS OF PARALLEL TASKS DURING UNREP

One of the goals of this research was to show the parallelism between the tasks that each of the bridge watch team members must perform during an UNREP. Since bridge teams normally consist of approximately ten or more personnel, most evolutions are accomplished with teamwork. While one team member is performing task A, another member may be working on task B and task B may require task A to be completed prior to task B being completed. In other words, many tasks are executed in parallel. In an effort to capture this parallelism, several parallel programming and task analysis notations were considered, but none of them quite captured the parallel nature of the tasks. For instance, CPM GOMS was strongly considered. However, it is normally used to show the parallelism between tasks within a single person. Thus, the table below was created to capture the sequential as well as parallel aspects of the UNREP task. Sequential tasks required of each watch stander are listed by column from top to bottom. On the other hand, when the table is read by row across each watch stander, the parallelism of task execution can be easily understood. The outline numbers associated with the tasks indicate what level the task would be in CMN GOMS notation. For instance, a two-digit

(0.0) numbered task in the table would be a functional level task in CMN GOMS notation and tasks with three or more digit number are the subtasks of functional tasks.

Parallel Task Table				
Time	**Conning Officer**	**Officer Of The Deck**	**Helmsman**	**Lee Helmsman**
	1.0 – Complete Brief Phase	1.0 - Complete Brief Phase		
	1.1 – Know UNREP Plan	1.1 - Know UNREP Plan		
	1.2 – Know Plant Configuration	1.2 - Know Plant Configuration	1.0 - Take Helmsman Watch	1.0 - Take Lee Helmsman Watch
Start 00:00	2.0 – Complete Approach Phase	2.0 - Complete Approach Phase	2.0 - Complete Approach Phase	2.0 - Complete Approach Phase
	2.1 – Know UNREP Plan	2.1 - Know UNREP Plan		
	2.1.1 - Know Plant Configuration	2.1.1 - Know Plant Configuration		
	2.1.2 – Determine Side To Approach On	2.1.2 - Determine Side To Approach On	2.1 Maintain Ordered Course **(Loops until new order received)**	2.1 - Maintain Ordered Speed **(Loops until new order received)**
	2.1.3 – Go To Appropriate Bridge Wing	2.2 - Supervise Bridge Watch Team	2.1.1 - Steer To Maintain Ordered Course	2.2 – Maintain Communications **(Periodic Task)**
			2.2 – Maintain Communications **(Periodic Task)**	
	2.2 – Maintain Communications **(Periodic Task)**	2.2.1 - Ensure Bridge Manned & Ready		
		2.2.1.1 - Correct Discrepancies		
	2.3 – Maintain Awareness Of Third Party Ships **(Periodic Task)**	2.2.2 - Ensure All Communications Equipment Operational		

Table 2: Parallel Task Table for UNREP Watch Team

Parallel Task Table				
Time	**Conning Officer**	**Officer Of The Deck**	**Helmsman**	**Lee Helmsman**
00:05	2.4 – Maintain Station **(Loops until approach starts)**	2.2.3 - Ensure All Bridge Equipment Setup and Operational		
	2.4.1 - Shoot Bearings To Replenishment Ship	2.2.4 - Ensure All Bridge Watch Standers Remain Alert **(Periodic Task)**		
	2.4.2 - Get Range To Replenishment Ship	2.3 - Maintain Communications **(Periodic Task)**		
	2.4.3 – Determine If On Station	2.4 - Ensure Own Ship Ready To Go Alongside		
	2.4.3.1 – Determine If Range To Replenishment Ship Correct	2.5 – Maintain Awareness Of Third Party Ships **(Periodic Task)**		
	2.4.3.2 – Determine If Bearing To Replenishment Ship Correct	2.6 - Ensure Conning Officer Maintains Station		
	2.4.4 - Make Necessary Corrections **(Assume On Station, No Corrections Required)**			
00:10	2.5 – Receive Report Own Ship Ready To Go Alongside	2.4.1 – Inform CO Ship Is Manned And Ready To Go Alongside		
	2.5.1 – Acknowledge Receiving Report			
	2.3 – Maintain Awareness Of Third Party Ships **(Periodic Task)**			
	2.5.2 - Order ROMEO Close-up On The Side That Will Go Alongside (OOD may do this)	2.4.2 – Order ROMEO Close-up On The Side That Will Go Alongside		
00:15	2.6 – Make Approach	2.6 - Supervise Make Approach		
	2.6.1 - Observe ROMEO Close-up On Replenishment Ship	2.6.1 - Observe ROMEO Close-up On Replenishment Ship		
	2.6.2 - Receive Approach Order From CO	2.6.2 Order Conning Officer To Commence Approach (From CO)		

Table 2: Parallel Task Table for UNREP Watch Team (Continued)

Parallel Task Table				
Time	**Conning Officer**	**Officer Of The Deck**	**Helmsman**	**Lee Helmsman**
	2.6.2.1 - Acknowledge Receiving Order			
	2.6.3 - Change Speed Of Ship	2.6.3 - Monitor Conning Officer During Maneuver 2.6.3.1 - Correct Conning Officer As Necessary		
	2.6.3.1 - Issue Engine Order 2.6.3.1.1 - Increase Speed 2.6.3.1.1.1 - Determine Desired Speed 2.6.3.1.1.2 – Give Verbal Order To Lee Helm			2.3 – Change Speed As Ordered 2.3.1 –Receive Engine Order
	2.6.3.2 - Receive Repeat-back (Lee Helm)			2.3.2 – Repeat Order Back To Conning Officer
	2.6.3.2.1 – Acknowledge Repeat-back (Lee Helm)			2.3.3 – Change Throttle To Match RPM of Ordered Speed
	2.6.4 - Turn Ship			2.3.3 .1 - Receive Acknowledgement
	2.6.4.1 - Visually Verify Direction Clear			
	2.6.4.2 - Issue Rudder Order 2.6.4.2.1 - Starboard Turn			
00:20	2.6.4.2.1.1 - Determine How Far To Turn 2.6.4.2.1.2 - Determine Degree Of Rudder To Use 2.6.4.2.1.3 - Give Verbal Order To Helm		2.3 – Turn Ship As Ordered 2.3.1 - Receive Order From Conning Officer	
	2.6.4.3 – Receive Repeat-back (Helm)		2.3.1.1 - Repeat Order Back To Conning Officer 2.3.2 - Turn The Wheel	
	2.6.4.3.1 Acknowledge Repeat-back (Helm)		2.3.1.1.1 -Receive Acknowledgment	

Table 2: Parallel Task Table for UNREP Watch Team (Continued)

Parallel Task Table				
Time	**Conning Officer**	**Officer Of The Deck**	**Helmsman**	**Lee Helmsman**
	2.5.3.3 – Determine If Order Was Executed (Engine)	2.6.4 - Determine Range To Replenishment Ship		
	2.5.3.4 – Receive Report Order Was Executed (Lee Helm)	2.6.5 – Determine Range Closing/Opening Rate		2.3.3.1.1 - Report Pitch/RPM Change To Conning Officer
	2.5.3.4.1 – Acknowledge Report (Lee Helm)			2.3.3.1.1.1 - Receive Acknowledgement
	2.6.4.4 – Determine If Order Was Executed (Turn)	2.5 – Maintain Awareness Of third Party Ships **(Periodic Task)**		2.4 - Maintain Ordered Speed **(Loops until new order received)**
	2.6.4.5 – Receive Report That Order Was Executed (Helm)	2.6.6 – Determine Lateral Separation Closing Opening	2.3.1.2 - Report That The Wheel Is Over To The Conning Officer	2.2 – Maintain Communications **(Periodic Task)**
	2.3 – Maintain Awareness Of third Party Ships **(Periodic Task)**	2.6.6.1 – Shoot Bearing To Replenishment Ship		
	2.6.4.5.1 – Acknowledge Report (Helm)		2.3.1.2.1 - Receive Acknowledgement	
	2.6.5 – Monitor Ship's Turn		2.3.2 - Monitor Turn 2.2.3 - Stop Ship's Turn On Ordered Course	
	2.6.6 - Monitor Helmsman		2.3.3.1 - Reduce Degree Of Rudder To Slow Swing Of Ship 2.3.3.2 - Stop The Swing Of The Ship 2.3.3.2.1 - Counter Steer To Stop Swing Of The Ship	
	2.6.7 – Receive Steady On Course Report (Helm)		2.3.3.3 – Report Steady On Ordered Course To Conning Officer	

Table 2: Parallel Task Table for UNREP Watch Team (Continued)

Parallel Task Table				
Time	**Conning Officer**	**Officer Of The Deck**	**Helmsman**	**Lee Helmsman**
	2.6.7.1 – Acknowledge Report (Helm)		2.3.3.3.1- Receive Acknowledgement	
	2.6.8 - Make Necessary Corrections (**Assume Lateral Separation Must be Increased)**		2.4 - Maintain Ordered Course (Loops until new order received)	
	2.6.9 – Turn Ship		2.4.1 - Steer To Maintain Ordered Course 2.2 – Maintain Communications **(Periodic Task)**	
	2.6.9.1 – Visually Verify Direction Clear	2.6.7 - Monitor Conning Officer During Maneuver		
	2.6.9.2 - Issue Rudder Order 2.6.9.2.1 – Starboard Turn			
	2.6.9.2.1.1 - Determine How Far To Turn 2.6.9.2.1.2 - Determine Degree Of Rudder To Use 2.6.9.2.2 - Give Verbal Order To Helm		2.5 – Turn Ship As Ordered 2.5.1 – Receive Order From Conning Officer	
	2.6.9.3 - Receive Repeat-back (Helm)	2.5 - Maintain Awareness Of third Party Ships **(Periodic Task)**	2.5.1.1 - Repeat Order Back To Conning Officer 2.5.2 - Turn The Wheel	
	2.6.9.3.1 – Acknowledge Repeat-back (Helm)		2.5.1.1.1 -Receive Acknowledgment	
	2.6.9.4 – Determine If Order Was Executed (Turn)			
	2.6.9.5- Receive Report That Order Was Executed (Helm)		2.5.1.2 - Report That The Wheel Is Over To The Conning Officer	
	2.6.9.5.1 – Acknowledge Report (Helm)		2.5.1.2.1 - Receive Acknowledgement	
	2.6.10- Monitor Ship's Turn	2.6.8 - Monitor Ship's Turn	2.5.2 - Monitor Turn 2.5.3 - Stop Ship's Turn On Ordered Course	

Table 2: Parallel Task Table for UNREP Watch Team (Continued)

Parallel Task Table				
Time	**Conning Officer**	**Officer Of The Deck**	**Helmsman**	**Lee Helmsman**
	2.6.10.1 – Monitor Helmsman	2.6.9 - Monitor The Conning Officer 2.6.9.1 - Correct Conning Officer As Necessary	2.5.3.1 - Reduce Degree Of Rudder To Slow Swing Of Ship 2.5.3.2 - Stop The Swing Of The Ship 2.5.3.2.1 - Counter Steer To Stop Swing Of The Ship	
	2.6.11 - Make Necessary Corrections (**Assume No Corrections Required)**			
	2.6.12 – Receive Steady On Course Report		2.5.3.3 – Report Steady On Ordered Course To Conning Officer	
	2.6.12.1– Acknowledge Receiving Report		2.5.3.4 – Receive Acknowledgement	
	2.6.13 – Get Range To Replenishment Ship		2.6 Maintain Ordered Course (Loops until new order received) 2.6.1 - Steer To Maintain Ordered Course 2.2 – Maintain Communications **(Periodic Task)**	
	2.6.13.1 – Determine Range Opening/Closing Rate			
	2.6.14 - Shoot Bearing To Replenishment Ship	2.5 – Maintain Awareness Of third Party Ships **(Periodic Task)**		
	2.6.15 – Determine If Lateral Separation Closing/ Opening	2.6.10 – Determine If Lateral Separation Closing/ Opening		
	2.6.16 – Determine If Lateral Separation Too Close/Far	2.6.11 – Determine If Lateral Separation Too Close/Far		
	2.6.16.1 - Make Necessary Corrections (**Assume No Corrections Required)**			
	2.6.17 - Determine If Lateral Separation Is Safe To Go Alongside			

Table 2: Parallel Task Table for UNREP Watch Team (Continued)

Parallel Task Table				
Time	**Conning Officer**	**Officer Of The Deck**	**Helmsman**	**Lee Helmsman**
	2.6.17.1 - Make Necessary Corrections (**Assume No Corrections Required**)	2.6.12 - Monitor Bow As It Approaches Replenishment Ship's Stern		
	2.6.18 - Monitor Bow As It Approaches Replenishment Ship's Stern			
00:25	3.0 – Complete Alongside Phase	3.0 – Complete Alongside Phase		
	3.1 - Determine When Bow Crosses Stern	3.1 - Determine When Bow Crosses Stern		
	3.2 - Watch For Bow To Be Pushed Away From Replenishment Ship	3.2 - Supervise Bridge Watch Team 3.2.1 - Ensure All Personnel Are Alert 3.2.2 - Maintain Quiet Bridge		
	3.3 - Monitor Venturi Effect Alongside Replenishment Ship	3.3 - Monitor Venturi Effect Alongside Replenishment Ship		
	3.3.1 - Monitor Lateral Separation	3.3.1 - Monitor Lateral Separation		
	3.3.1.1 - Make Necessary Corrections (**Assume Too Close**)			
	3.3.1.1.1 - Turn Ship			
	3.3.1.1.1.1 - Issue Rudder Order 3.3.1.1.1.1.1 - Starboard Turn	3.4 - Supervise Conning Officer While Alongside 3.4.1 - Monitor Conning Officer During Maneuver 3.4.1.2 - Correct Conning Officer As Necessary		
	3.3.1.1.1.1.1.1 - Determine How Far To Turn 3.3.1.1.1.1.1.2 - Determine Degree Of Rudder To Use 3.3.1.1.1.1.1.3 - Give Verbal Order To Helm		2.7 – Turn Ship As Ordered 2.7.1 - Receive Order From Conning Officer	

Table 2: Parallel Task Table for UNREP Watch Team (Continued)

Parallel Task Table				
Time	**Conning Officer**	**Officer Of The Deck**	**Helmsman**	**Lee Helmsman**
	3.3.1.1.2 – Receive Repeat Back (Helm)		2.7.1.1 - Repeat Order Back To Conning Officer 2.7.2 - Turn The Wheel	
	3.3.1.1.2.1 – Acknowledge Repeat-back		2.7.1.1.1 -Receive Acknowledgment	
	3.3.1.1.3 – Determine If Order Was Executed (Turn)			
	3.3.1.1.4 – Receive Report That Order Was Executed (Helm)		2.7.1.2 - Report That The Wheel Is Over To The Conning Officer	
	3.3.1.1.4.1 – Acknowledge Report		2.7.1.2.1 – Receive Acknowledgement	
	3.3.1.2 – Monitor Ship's Turn			
	3.3.1.2.1 – Monitor Helmsman			
	3.3.1.3 - Receive Steady On Course Report		2.7.1.3 – Report Steady On Ordered Course To Conning Officer	
	3.3.1.3.1 - Acknowledge Report	3.5 – Determine Range To Station Closing Rate	2.7.1.3.1 - Receive Acknowledgement	
	3.4 – Determine Lateral Separation	3.5.1 – Determine Range To Station	2.8 Maintain Ordered Course (Loops until new order received) 2.8.1 - Steer To Maintain Ordered Course 2.2 – Maintain Communications **(Periodic Task)**	
	3.4.1 - Make Necessary Corrections (**Assume No Corrections Required)**	3.6 - Monitor Conning Officer 3.6.1 - During Maneuver Correct Conning Officer As Necessary		
	3.5 – Determine Range To Station Closing Rate			
	3.5.1 – Determine Range To Station			
	3.5.2 - Make Necessary Corrections (**Assume No Corrections Required)**			

Table 2: Parallel Task Table for UNREP Watch Team (Continued)

Parallel Task Table				
Time	**Conning Officer**	**Officer Of The Deck**	**Helmsman**	**Lee Helmsman**
00:27	3.6 – Determine When To Match Speeds 3.6.1 - Change Speed Of Ship	3.7 – Determine When To Match Speeds		
	3.6.1.1 – Issue Engine Order			
	3.6.1.1.1 – Decrease Speed			
	3.6.1.1.1.1 – Determine Desired Speed			
	3.6.1.1.1.2 – Give Verbal Order To Lee Helm			3.1 - Change Speed As Ordered 3.1.2 - Receive Engine Order
	3.6.1.2 Receive Repeat-back From Lee Helm			3.1.3 - Repeat Order Back To Conning Officer 3.1.4 - Change Throttle To Match RPM of Ordered Speed
	3.6.1.2.1 – Acknowledge Repeat-back (Lee Helm)			3.1.5 - Receive Acknowledgement
	3.6.1.3 – Determine If Order Was Executed			
	3.6.1.4 – Receive Report That Order Was Executed			3.2.3.1 - Report Pitch/RPM Change To Conning Officer
	3.6.1.4.1 – Acknowledge Report (Lee Helm)			3.2.3.1.2 - Receive Acknowledgement
	3.7 – Maneuver Close To Station Alongside	3.8 – Maneuver Close To Station Alongside		3.3 - Maintain Ordered Speed **(Loops until new order received)** 2.2 – Maintain Communications **(Periodic Task)**
	3.7.1 – Monitor Ship's Heading On Gyrocompass	3.8.1 – Monitor Ship's Heading On Gyrocompass		
	3.7.2 – Monitor Lateral Separation	3.8.2 – Monitor Lateral Separation		
	3.7.3 – Monitor Fore And Aft Motion	3.8.3 – Monitor Fore And Aft Motion		
	3.7.4 – Make Necessary Corrections (**Assume On Station, No Corrections Required)**			

Table 2: Parallel Task Table for UNREP Watch Team (Continued)

Parallel Task Table				
Time	**Conning Officer**	**Officer Of The Deck**	**Helmsman**	**Lee Helmsman**
00:35	3.8 – Get Phone And Distance Line Across	3.9 – Get Phone And Distance Line Across		
	3.9 – Maintain Station Alongside **(LOOP until Breakaway)**	3.10 – Maintain Station Alongside **(LOOP until Breakaway)**		
	3.9.1 – Monitor Lateral Separation	3.10.1 – Monitor Lateral Separation		
	3.9.2 – Monitor Fore And Aft Motion	3.10.2 – Monitor Fore And Aft Motion		
	Tension lines 3.9.3 – Make Necessary Corrections **(Assume Too Far & Falling Back)**			
	3.9.3.1 - Turn Ship			
	3.9.3.1.1 - Issue Rudder Order 3.9.3.1.1.1 - Port Turn	3.10.3 - Monitor Progress Of Stores And Fuel Transfer		
	3.9.3.1.1.1.1 – Determine How Far To Turn 3.9.3.1.1.1.2 – Determine Degree Of Rudder To Use 3.9.3.1.1.1.3 – Give Verbal Order To Helm	3.10.4 - Monitor Conning Officer During Maneuver 3.10.4.1 - Correct Conning Officer As Necessary	2.9 – Turn Ship As Ordered 2.9.1 - Receive Order From Conning Officer	
	3.9.3.1.2 – Receive Repeat-back From Helm		2.9.1.1 - Repeat Order Back To Conning Officer 2.9.2 - Turn The Wheel	
	3.9.3.1.2.1 – Acknowledge Repeat-back (Helm)		2.9.1.1.1 -Receive Acknowledgment	
	3.9.3.2 – Change Speed Of Ship			
	3.9.3.2.1 – Issue Engine Order	2.5 – Maintain Awareness Of third Party Ships **(Periodic Task)**		
	3.9.3.2.1.1 – Increase Speed			
	3.9.3.2.1.1.1 – Determine Desired Speed			

Table 2: Parallel Task Table for UNREP Watch Team (Continued)

Parallel Task Table				
Time	**Conning Officer**	**Officer Of The Deck**	**Helmsman**	**Lee Helmsman**
	3.9.3.2.1.1.2 – Give Verbal Order To Lee Helm			3.4.1 - Change Speed As Ordered 3.4.2 - Receive Engine Order
	3.9.3.2.2 – Receive Repeat-back (Lee Helm)	3.10.5 - Determine Where Own Ship Will Go After UNREP		3.4.3 - Repeat Order Back To Conning Officer
	3.9.2.1.3 – Determine If Order Was Executed (Turn)			3.4.4 - Change Throttle To Match RPM of Ordered Speed
	3.9.3.2.2.1 - Acknowledge Report (Lee Helm)			3.4.4.1 - Receive Acknowledgement
	3.9.2.2 – Receive Report That Order Was Executed (Helm)		2.9.1.2 - Report That The Wheel Is Over To The Conning Officer	
	3.9.2.2.1 – Acknowledge Report (Helm)		2.9.1.2.1 - Receive Acknowledgement	
	3.9.3.3 – Determine If Order Was Executed (Lee Helm)			
	3.9.2.3 – Monitor Ship's Turn			
	3.9.2.4 – Monitor Helmsman			
	3.9.3.3.1- Receive Report That Order Was Executed (Lee Helm)	3.10.6 - Monitor Bridge Watch Team		3.4.4.2 - Report Pitch/RPM Change To Conning Officer
	3.9.2.5 – Receive Steady On Course Report (Helm)		2.9.1.3 - Report Steady On Course To Conning Officer	
	3.9.3.3.1.1 - Acknowledge Report (Lee Helm)			3.4.4.2.1 - Receive Acknowledgement
00:40	3.9.2.6 – Acknowledge Report (Helm) **(Loop To Maintain Station)**		2.9.1.3.1 -Receive Acknowledgement	3.5 - Maintain Ordered Speed **(Loops until new order received)** 2.2 – Maintain Communications **(Periodic Task)**

Table 2: Parallel Task Table for UNREP Watch Team (Continued)

Parallel Task Table				
Time	**Conning Officer**	**Officer Of The Deck**	**Helmsman**	**Lee Helmsman**
02:30	4.0 - Complete Breakaway Phase	4.0 - Complete Breakaway Phase	2.10 - Maintain Ordered Course **(Loops until new order received)** 2.10.1 - Steer To Maintain Ordered Course 2.2 – Maintain Communications **(Periodic Task)**	
	2.3 - Maintain Awareness Of Third Party Ships **(Periodic Task)**	2.5 – Maintain Awareness Of third Party Ships **(Periodic Task)**		
	4.1 - Maintain Station Alongside **(LOOP)**	4.1 – Maintain Station Alongside **(LOOP)**		
	4.1.1 - Monitor Lateral Separation	4.1.1 – Monitor Lateral Separation		
	4.1.2 - Monitor Fore And Aft Motion			
	4.2 - De-tension Lines			
	4.1.3 – Make Necessary Corrections **(Assume No Corrections Required)**			
	4.3 - Determine All Lines Clear	4.2 – Determine All Lines Clear		
	4.4 - Receive Breakaway Order From CO	4.3 - Receive Breakaway Order From CO		
	4.4.1 – Acknowledge Receiving Order			
	4.5 – Breakaway	4.4 – Breakaway		
	4.5.1 - Change Speed Of Ship			
	4.5.1.1 – Issue Engine Order			
	4.5.1.1.1 – Determine Desired Speed			
	4.5.1.2 – Give Verbal Order To Lee Helm			4.1 - Change Speed As Ordered 4.1.1 - Receive Engine Order
	4.5.1.3 – Receive Repeat-back From Lee Helm			4.1.1.1 - Repeat Order Back To Conning Officer 4.1.2 - Change Throttle To Match RPM of Ordered Speed

Table 2: Parallel Task Table for UNREP Watch Team (Continued)

Parallel Task Table				
Time	**Conning Officer**	**Officer Of The Deck**	**Helmsman**	**Lee Helmsman**
	4.5.1.3.1 - Acknowledge Report (Lee Helm)			4.1.2.1 - Receive Acknowledgement
	4.5.2 - Turn Ship			
	4.5.2.1 – Visually Verify Direction Of Turn Clear	2.5 – Maintain Awareness Of third Party Ships **(Periodic Task)**		
	4.5.2.2 - Issue Rudder Order			
	4.5.2.2.1- Starboard Turn			
	4.5.2.2.1.1 - Determine How Far To Turn			
	4.5.2.2.1.2 – Determine Degree Of Rudder To Use			
	4.5.2.2.2 – Give Verbal Order To Helm	4.4.1 - Monitor Conning Officer During Maneuver 4.4.1.1 - Correct Conning Officer As Necessary	2.11 – Turn Ship As Ordered 2.11.1 - Receive Order From Conning Officer	
	4.5.2.3 – Receive Repeat-back From Helm		2.2.1.1 - Repeat Order Back To Conning Officer 2.11.2 - Turn The Wheel	
	4.5.2.3.1 - Acknowledge Report (Helm)		2.11.2 - Receive Acknowledgement	
	4.6.1 - Monitor Ship's Turn			
	4.5.1.4 – Determine If Order Was Executed (Engine)			
	4.5.2.4 - Determine If Order Was Executed (Turn)			
	4.6.2 – Monitor Helmsman			
	4.5.1.5 - Receive Report That Order Was Executed (Lee Helm)			4.1.3 - Report Pitch/RPM Change To Conning Officer
	4.5.1.5.1 – Acknowledge Report (Lee Helm)			4.1.3.1 - Receive Acknowledgement

Table 2: Parallel Task Table for UNREP Watch Team (Continued)

Parallel Task Table				
Time	**Conning Officer**	**Officer Of The Deck**	**Helmsman**	**Lee Helmsman**
	4.5.2.5 - Receive Report That Order Was Executed (Helm)		2.11.1.2 - Report That The Wheel Is Over To The Conning Officer	4.2 - Maintain Ordered Speed **(Loops until new order received)**
	4.5.2.5.1 – Acknowledge Report (Helm)		2.11.1.2.1 - Receive Acknowledgement	2.2 – Maintain Communications **(Periodic Task)**
	4.5.3 – Make Necessary Corrections **(Assume No Corrections Required)**	4.4.2 - Monitor Conning Officer During Maneuver 4.4.2.1 - Correct Conning Officer As Necessary		
	4.7 – Determine Stern Is Clear			
	4.8 – Turn Ship			
	4.8.1 – Visually Verify Direction Of Turn Clear			
	4.8.2 – Issue Rudder Order			
	4.8.2.1 – Starboard Turn			
	4.8.2.1.1 – Determine How Far To Turn			
	4.8.2.1.2 – Determine Degree Of Rudder To Use			
	4.8.2.2 – Give Verbal Order To Helm	2.5 – Maintain Awareness Of third Party Ships **(Periodic Task)**	2.12 – Turn Ship As Ordered 2.12.1 - Receive Order From Conning Officer	
	4.8.2.2.1 - Acknowledge Report (Helm)		2.12.3 - Receive Acknowledgement	
	4.8.2.2.1.1 – Receive Repeat-back From Helm		2.12.1.1 - Repeat Order Back To Conning Officer 2.12.2 - Turn The Wheel	
	4.8.2.3 – Determine If Order Was Executed (Turn)			
	4.8.2.4 – Receive Report That Order Was Executed (Helm)		2.12.1.2 - Report That The Wheel Is Over To The Conning Officer	

Table 2: Parallel Task Table for UNREP Watch Team (Continued)

Parallel Task Table				
Time	**Conning Officer**	**Officer Of The Deck**	**Helmsman**	**Lee Helmsman**
	4.8.2.4.1 – Acknowledge Report (Helm)		2.12.1.3 - Receive Acknowledgement	
	4.8.3 - Monitor Ship's Turn			
	4.8.4. - Receive Steady On Course Report		2.12.1.2 - Report Steady On Course To Conning Officer	
	4.8.4.1 - Acknowledge Report (Helm)		2.12.1.2.1 - Receive Acknowledgement	
	4.8.5 – Monitor Helmsman			
	4.8.6 – Make Necessary Corrections **(Assume No Corrections Required)**			
02:35 End	4.9 - Go To Next Station Or Duties Assigned			

Table 2: Parallel Task Table for UNREP Watch Team (Continued)

F. VALIDATION OF THE TASK ANALYSIS

With the task analysis completed, the remaining goal of the thesis was to have the task analysis validated by experienced ship-handlers. This goal was accomplished by having five SWOs of various experience levels individually review the task analysis for accuracy and completeness. Each participant signed an agreement to participate in the validation anonymously. Participants were asked to read a one page brief on the notations used to describe the tasks, followed by a list of goals that would be accomplished during the review. These goals were as follows:

- Identify any discrepancies in the Conning Officer GOMS-like sequential UNREP task analysis.

- Identify any missing goals, tasks and/or methods a Conning Officer is required to perform during an UNREP.
- Identify any missing visual or audible cues that a Conning Officer may use to recognize or monitor progress during an UNREP.

Participants were also given a copy of the same assumptions for the UNREP scenario as were listed previously in this chapter on page 49. Each review was scenario based and was conducted in a format similar to a SWO board. The researcher verbally built a scenario while reading through the task analysis notation and participants followed along with their own copy of the analysis. This method was determined to be the most expedient way to review the large volume of information. At any time during the scenario that a reviewer thought a task was missing or out of place, they stopped the researcher and expressed their concern. The researcher recorded the discrepancy and then continued building the scenario. The review process took approximately an hour per session.

The following is a brief profile of the naval personnel who reviewed the task analysis. All were qualified Surface Warfare Officers. One was a post Commanding Officer, two were post Executive Officers, one post Department Head and one post Division Officer. There were two Commanders, one Lieutenant Commander and two Lieutenants. The two Commanders are currently Curriculum Officers at the Naval Postgraduate School, while the others are non-computer science graduate students.

The validation reviews proved to be very useful and resulted in several revisions to the task analysis. The most significant correction was the addition of the goal:

Inform_Helmsman_Before_Lines_Are_Tensioned. This was a very important addition since failing to accomplish this goal could result in a collision. Other corrections were relatively minor in comparison. All corrections were made and the task analysis is an accurate and complete representation of the tasks performed by a bridge watch team in general and specifically the Conning Officer during an UNREP.

VI. CONCLUSIONS

A. SUMMARY OF WORK

Training ship-handlers is a long, costly and difficult task. The simulators available today are costly and available to only a relatively few ship drivers. The Surface Warfare Officers School (SWOS) has recognized the tremendous capabilities of VE technology and is pushing the envelope in an effort to train Surface Warriors better, faster and cheaper. Researchers at the Naval Air Warfare Center Training Systems Division (NAWC TSD) have developed a test-bed called the Conning Officers Virtual Environment (COVE). COVE currently provides only a limited Underway Replenishment (UNREP) scenario. The purpose of this thesis was to provide a cognitive task analysis to ensure that the UNREP scenario developed for the actual simulator delivered to SWOS is based on the tasks that a Conning Officer must be able to perform during a real world UNREP. As the COVE project advances to the next level of development, the need to keep experienced ship-handlers in the development loop is essential. The research for this thesis was done and reviewed by experienced ship-handlers.

At the request of researchers at the NAWC TSD, a cognitive task analysis of a Conning Officer during an UNREP was constructed. After a thorough literature review and preliminary task analysis, the UNREP task was determined to consist of sequential as well as parallel tasks. This implies that not only does the Conning Officer perform

sequential and parallel tasks, but he also performs tasks in parallel to tasks that other bridge watch standers perform. In some cases, there are even tasks that are executed in sequence with other watch stander tasks.

Various notations and methodologies were considered before the CMN GOMS notation was chosen. CMN GOMS is a serial notation and was easily modified to capture the tasks that make up UNREP. The first step was to determine what tasks a Conning Officer must accomplish to drive a ship during an UNREP. Once this was done, the tasks were named and sorted into levels of analysis, i.e. Unit-Level, Functional-Level and Detailed-Level. Tasks performed in parallel with tasks executed by other watch standers were also documented. Next, the tasks each watch stander performed were placed in a CMN GOMS-like notation, the difference being that true CMN GOMS notation is sequential. As it is used here, it is intended to allow tasks to repeat periodically, as well as to allow task sequences to loop for long periods of time. These modifications were necessary for two reasons; first, there are many ways to do a UNREP, and second, UNREP is a very long task, often lasting for over three hours. Thus, during a particular phase of an UNREP, the same sequence of tasks may loop several times while other tasks may occur periodically during periods when the Conning Officer's task load is low.

After all tasks were placed into the CMN GOMS-like notation, a table that illustrates a typical UNREP was constructed, with watch standers' sequential tasks in columns and parallel tasks in rows. This allows the reader to read down the Conning Officer column and understand a typical sequence of tasks a Conning Officer must

perform. To get a snapshot of the possible parallel tasks taking place, the reader can read across a row.

Finally, in an effort to do quality assurance and to validate the task analysis, the analysis was presented to five Surface Warfare Officers of various ranks and experience. They were instructed to review the task analysis paying particular attention to identifying missing cues and tasks as well as the sequence in which the tasks occur. The information gathered during the validation interviews was used to update the CMN GOMS-like analysis and parallel task table. This validation process ensured that multiple experienced ship-handlers had reviewed the task analysis and that the analysis would be as complete and accurate as possible.

The result of the research was a validated sequential and parallel task analysis of the primary members of a bridge watch team during an UNREP. However, the analysis focused on the tasks executed by the Conning Officer during an UNREP. The other watch stander tasks were included to show the interaction between the Conning Officer and other watch standers that must be modeled to some degree in the VE scenario.

B. THESIS QUESTIONS

The following questions were addressed in this thesis:

- *What specific tasks are required of a Conning Officer during UNREP?*

  The use of the CMN GOMS task analysis notation to document the tasks required of a Conning Officer proved to be very successful. The CMN GOMS

notation highlighted the most significant tasks while still capturing the subtasks, methods and cues required to accomplish the tasks. This question was addressed in greater detail in chapter 5.

- *What are the cues used for ship handling during an UNREP?*

  The CMN GOMS notation can be expanded to capture various granularities of detail related to a given task. In this analysis, the method used to accomplish a given task details the cues necessary to accomplish the task. This question was addressed in detail in chapter 5.

- *What is a suitable level of analysis and associated methodology required to conduct a task analysis of a ship-handling task?*

  The CMN GOMS notation provides a suitable level of detail for conducting a cognitive task analysis of a single watch stander for virtual environment scenario development. However, most shipboard tasks take a significant amount of time and are accomplished by teamwork. This aspect is not easily captured with CPM GOMS notation or any other notation found during the literature review for this thesis.

C. RECOMMENDATIONS FOR FUTURE WORK

1. Future Scenarios

The following is a list of future scenarios that would provide beneficial training experiences for Conning Officers:

- Rules of the Road tutorial
- Maneuvering in restricted waters (shallow underwater obstacles)
- Maneuvering in shallow vs. deep water (different ship-handling characteristics)
- Maneuvering through a heavy traffic environment (an armada of fishing vessels)
- Flight quarters maneuvering
- Minefield maneuvering
- Harbor navigation (good daytime visibility, low visibility, nighttime)
- Plane guard (stationed 1000 yards behind an Aircraft Carrier)
- Division tactics (formation steaming with one or more additional ships)
- Anchoring
- Station keeping (maneuvering in a various screen formations)
- Man overboard maneuvers (all different patterns)
- Night time contact light configuration (opening, closing, crossing)
- Approaching a pier (with or without tugs)
- Casualty control (loss of a shaft, loss of steering)

- Collision avoidance and recovery

Each scenario should be able to implement one or more of the following variables: location (Blue water/Brown water), time of day (light/dark), wind (direction/speed), current (direction/speed), ship's speed and engine configuration, visibility (fog/rain), sea state, trailing a towed array, depth of water and the number of contacts around own ship. Since most critical ship-handling situations take time to develop, the key to avoiding problems at sea is to recognize a possible problem early, take appropriate action early, and monitor the result to ensure the action taken corrected the problem. For example, if the Conning Officer recognizes that a contact on the horizon will pass own ship at an unacceptable range, the Conning Officer can make a slight course change early to avoid this situation. However, if the Conning Officer waits until the contact is ten thousand yards away, a significant course and speed change will be required to avoid the contact. This illustrates that scenarios must be scripted to develop over time and provide the user with the same cues that are used to make decisions at sea. Another variable that exists is the personnel, since some personnel may play major rolls in one scenario and have a relatively insignificant roll in another. For instance, in most restricted waters such as a harbor, a pilot will come onboard and in some cases the pilot may not be up to standards or a language barrier may exist. Since the ship's CO is ultimately responsible for the ship, when this situation occurs the CO, Navigator and Conning Officer will have to work harder to insure the safety of the ship.

Implementing the variables discussed above will allow the instructor to customize each scenario run for a specific level student. Although it appears that COVE is currently being targeted at the intermediate ship-handlers at SWOS Department Head School, it is believed that this tool will have a significant impact in training Division Officer Course students as well. Inexperienced ship-handlers could be given relatively simple Rules of the Road scenarios, while intermediate ship drivers could practice casualty control scenarios and the advanced ship drivers could do emergency collision avoidance and recovery scenarios. Currently a means to practice collision avoidance and recovery does not exist. This simulator should allow collisions to occur, so that personnel can learn from their mistakes and determine which emergency maneuvers work best in a given situation, as well as develop know emergency techniques. Emergency scenarios could be replayed so that case studies can be used to evaluate the officers actions to determine what works or doesn't work. This capability alone would be a major advancement in training capability.

2. Virtual CO

The Virtual CO would be a mechanism that acts like a real CO, i.e. an intelligent tutor. It would coach the Conning Officer during training exercises and it would establish and monitor ship-handling performance measures during scenarios. The Conning Officer would drive a ship in a VE scenario and the Virtual CO program would monitor the Conning Officer's performance. If the Conning Officer were to exceed some performance

criteria the Virtual CO would indicate to the Conning Officer what had been done wrong and how to correct the situation.

3. Naval Postgraduate School (NPS) Experiments

During discussions between NPS researchers and researcher from NAWC TSD, it was recognized that NPS offers a unique environment for ship-handling simulator development and testing. Two primary advantages were noted: (1) Most Surface Warfare Officers at NPS will attend SWOS Department Head School immediately following graduation, (2) NPS has domain area experts (SWOs) who have the opportunity to dedicate a year or more to research relevant to the development of a ship-handling simulator. These are largely untapped resources.

D. HOW TO USE THE TASK ANALYSIS

This task analysis should be used as a guide for COVE scenario developers and programmers. It provides an outline of the tasks that must be modeled or accounted for in the final COVE UNREP scenario. Additionally, the thesis lists many variables that should be able to be modified by the user/instructor through a graphical user interface to vary the level of difficulty of each scenario run. The use of this task analysis to develop simulator scenarios does not guarantee training transfer. However, it is an important step in the right direction. Experienced ship-handlers will find a scenario that closely represents the real world more engaging, and thus perceive that it is a beneficial training experience.

APPENDIX

A. TASK ANALYSIS OF A CONNING OFFICER DURING UNREP

1. Unit Task Level Analysis

goal: Execute_UNREP
. goal: Complete_Brief_Phase
. goal: Complete_Approach_Phase
. goal: Complete_Alongside_Phase
. goal: Complete_Breakaway_Phase

2. Functional Level Analysis

goal: Execute_UNREP
. goal: Complete_Brief_Phase
. . goal: Know_UNREP_Plan

. goal: Complete_Approach_Phase
. . goal: Know_UNREP_Plan
. . goal: Maintain_Communications
. . goal: Maintain_Awareness_Of_Third_Party_Ships
. . goal: Maintain_Station
. . goal: Receive_Report_Own_Ship_Ready_To_Go_Alongside
. . goal: Make_Approach
. goal: Complete_Alongside_Phase
. . goal: Determine_When_Bow_Crosses_Stern
. . goal: Watch_For_Bow_To_Be_Pushed_Away_From_Replenishment_Ship
. . goal: Monitor_Venturi_Effect_Alongside_Replenishment_Ship
. . goal: Determine_Lateral_Separation
. . goal: Determine_Range_To_Station_Closing_Rate
. . goal: Determine_When_To_Match_Speeds
. . goal: Maneuver_Close_To_Station_Alongside
. . goal: Get_Phone_And_Distance_Line_Across
. . goal: Maintain_Station_Alongside

. goal: Complete_Breakaway_Phase
. . goal: Maintain_Station_Alongside
. . goal: Determine_All_Lines_Clear
. . goal: Receive_Breakaway_Order_From_CO

. . goal: Breakaway
. . goal: Go_To_Next_Station_Or_Duties_Assigned

3. Detailed Level Analysis

goal: Execute_UNREP
. goal: Complete_Brief_Phase
. . goal: Know_UNREP_Plan
. . . [select: Go_To_OPS_Brief
. . . Go_To_CIC_Before_Watch
. . . Receive_UNREP_Brief_On_Bridge]
. . . goal: Know_Plant_Configuration
. . . . [select: Go_To_OPS_Brief
. . . . Go_To_CCS_Before_Watch
. . . . Receive_UNREP_Brief_on_Bridge]

.. goal: Complete_Approach_Phase
. . goal: Know_UNREP_Plan
. . . goal: Determine_Side_To_Approach_On
. . . . [select: Observe_ROMEO_Flag_On_Replenishment_Ship
. . . . Recall_From_Brief
. . . . Radio_Communication_With_Replenishment_Ship]
. . . goal: Know_Plant_Configuration
. . . . [select: Call_CCS_From_Bridge
. . . . Ask_Lee_Helm_To_Get_Configuration_From_CCS]
. . . goal: Go_To_Bridge_Wing
. . . . goal: Determine_Which_Bridge_Wing
. . . . . Chose_Side_That_Will_Be_To_Replenishment_Ship
. . goal: Maintain_Communications ...periodic task
. . . [select: Use_Amplified_Communications_System
. . . Yell_Through_Hatch ...if amp fail/not available
. . . Visual_Expressions ...for comms. with CO, OOD
. . . Verbal_Communications
. . . Use_Relay_Person] ... if amp fail/not available
. . . Verify_Order_Received
. . goal: Maintain_Awareness_Of_Third_Party_Ships ...periodic task
. . . [select: Visually_Scan_Horizon
. . . Listen_For_Contact_Reports
. . . Ask_OOD_About_Contacts]
. . goal: Maintain_Station ...loops until Make_ Approach executed
. . . goal: Shoot_Bearing_To_Replenishment_Ship ...frequently until alongside
. . . . [select: Use_Alidade_On_Bridge_Wing

. . . . Use_Radar_Bearing_To_Replenishment_Ship
. . . . Replenishment_Ship's_Masts_Lineup
. . . . Masthead_Lights_Of_Replenishment_Ship_Lineup ...at night
. . . . Own_Ship_In_Wake_Of_UNREP_Ship] ...at night/low vis
. . . goal: Get_Range_To_Replenishment_Ship ...frequently until alongside
. . . . [select: Get_Range_From_Stadimeter
. . . . Call_For_Radar_Range ...anytime and at night/low visibility
. . . . Visual_Estimate] ...in between updates
. . . goal: Determine_If_On_Station
. . . . goal: Determine_If_Range_To_Replenishment_Ship_Correct
. . . . . Compare_Range_With_Ordered_Range
. . . . goal: Determine_If_Bearing_To_Replenishment_Ship_Correct
. . . . . Compare_Bearing_With_Ordered_Bearing
. . . Verify_On_Station
. . . goal: Make_Necessary_Corrections ...loop back to Maintain _Station
. . . . [select goal: Turn_Ship ...see page 56
. . . . goal: Change_Speed_Of_Ship] ...see page 55
. . goal: Receive_Report_Own_Ship_Ready_To_Go_Alongside
. . . Receive_Verbal_Report_From_OOD
. . . goal: Acknowledge_Receiving_Report
. . . . Verbally_Repeat_Order_Received
. . . goal: Order_ROMEO_Raised_On_The_Side_To_Go_Alongside
. . . . Order_Signalman_To_The_Dip_ROMEO ...OOD may do this
. . goal: Make_Approach
. . . goal: Observe_ROMEO_Close-up_On_Replenishment_Ship
. . . . [select: Observe_ROMEO_Move_Up_On_Replenishment_Ship
. . . . Observe_Flashing_Light_Signal ...at night/low visibility
. . . . Receive_Radio_Transmission] ...at night/low visibility
. . . goal: Receive_Approach_Order_From_CO
. . . . [select: Receive_Verbal_Order_From_CO_To_Commence_Approach
. . . . Receive_Verbal_Order_Via_XO_To_Commence_Approach
. . . . Receive_Verbal_Order_Via_OOD_To_Commence_Approach]
. . . . goal: Acknowledge_Receiving_Order
. . . . . Verbally_Acknowledge_Order_Received
. . . goal: Order_ROMEO_Raised_On_The_Side_To_Go_Alongside
. . . . Order_Signalman_To_Close-up_ROMEO ...OOD may do this
. . . goal: Change_Speed_Of_Ship ...commence approach
. . . . goal: Issue_Engine_Order ...to lee helmsman
. . . . . [select goal: Increase_Speed
. . . . . . goal: Determine_Desired_Speed
. . . . [select: Use_Predetermined_Speed_From_UNREP_Brief
. . . . Use_Speed_CO_Orders

. . . . Use_Safe_Speed_For_Current_Weather_Conditions]
. . . . . . goal: Give_Verbal _Order_To_Lee_Helm
. . . . . goal: Decrease_Speed
. . . . . . goal: Determine_Desired_Speed
. . . . . . [select: Use_Predetermined_Speed_From_UNREP_Brief
. . . . . . Use_Speed_CO_Orders
. . . . . . Use_Safe_Speed_For_Current_Weather_Conditions]
. . . . . . goal: Give_Verbal_Order_To_Lee_Helm]
. . . . goal: Receive_Repeat-back_From_Lee_Helm
. . . . . Listen_For_Repeat-back_From_Lee_Helm
. . . . . [select goal: Acknowledge_Repeat-back ...if received
. . . . . goal: Repeat_Order] ...if not received
. . . . goal: Determine_If_Order_Was_Executed
. . . . . [select: Listen_For_Change_In_Engine_Sound
. . . . . Observe_Range_To_Replenishment_Ship_Close
. . . . . Observe_Target_Angle_Of_Replenishment_Ship_Change
. . . . . Observe_Feeling_Speed_Increase
. . . . . Observe_RPM_Indicator
. . . . . Observe_Increase_On_Speed_Indicator]
. . . . goal: Receive_Report_That_Order_Was_Executed
. . . . . Listen_For_Report_From_Lee_Helm
. . . . . [select goal: Acknowledge_Report ...if received
. . . . . goal: Request_Status_Of_Order_Execution] ...if not received
. . . goal: Turn_Ship ...to change lateral separation
. . . . goal: Visually_Verify_Direction_Of_Turn_Clear
. . . . . [select: Walk_To_Bridge_Wing_Of_The_Direction_Of_Turn_To_Look
. . . . . Request_Another_Watch_Team_Member_Visually_Check]
. . . . goal: Issue_Rudder_Order ...to helmsman
. . . . . [select goal: Starboard_Turn
. . . . . . goal: Determine_How_Far_T o_Turn
. . . . . . [select: Use_Prior_Experience_To_Estimate_Distance
. . . . . . Use_Radian_Rule_To_Monitor_Turn
. . . . . . Follow_CO's_Orders]
. . . . . . goal: Determine_Degree_Of_Rudder_To_Use
. . . . . . [select: Use_The_Rule_Of_Thirty_To_Determine_Amount
. . . . . . Use_Prior_Experience_To_Estimate_Amount
. . . . . . Follow_CO's_Orders]
. . . . . . goal: Give_Verbal_Order_To_Helm
. . . . . goal: Port_Turn
. . . . . . goal: Determine_How_Far_To_Turn
. . . . . . [select: Use_Prior_Experience_To_Estimate_Distance
. . . . . . Use_Radian_Rule_To_Monitor_Turn

. . . . Follow_CO's_Orders]
. . . . . . goal: Determine_Degree_Of_Rudder_To_Use
. . . . . . [select: Use_The_Rule_Of _Thirty_To_Determine _Amount
. . . . . . Use_Prior_Experience_To_Estimate_Amount
. . . . . . Follow_CO's_Orders]
. . . . . goal: Give_Verbal_Order_To_Helm]
. . . . goal: Receive_Repeat-back_From_Helm
. . . . . Listen_For_Report_From_Helm
. . . . . [select goal: Acknowledge_Repeat-back ...if received
. . . . . goal: Repeat_Order] ...if not received
. . . . goal: Determine_If_Order_Was_Executed
. . . . . [select: Observe_Rudder_Angle_Indicator
. . . . . Observe_Wake_Of_Replenishment_Ship
. . . . . Observe_Feeling _Ship_Heel
. . . . . Observe_Target_Angle_Of_Replenishment_Ship_Change
. . . . . Observe_Horizon
. . . . . Observe_Wake_Of_Own_Ship
. . . . . Observe_Gyrocompass_Heading_Change
. . . . . Observe_Feeling_That_Ship_Is_Turning]
. . . . goal: Receive_Report_That_Order_Was_Executed
. . . . . Listen_For_Report_From_Helmsman
. . . . . [select goal: Acknowledge_Report ...if received
. . . . . goal: Request_Status_Of_Order_Execution] ...if not received
. . . goal: Monitor_Ship's_Turn
. . . . [select: Observe_Rudder_Angle_Indicator
. . . . Observe_Feeling_Ship_Heel
. . . . Observe_Wake_Of_Replenishment_Ship
. . . . Observe_Wake_Of_Own_Ship
. . . . Observe_Horizon
. . . . Observe_Gyrocompass_Heading_Change
. . . . Observe_Feeling_That_Ship_Is_Turning
. . . . Observe_Rate_Of_Turn_ Increase/ Decrease]
. . . . goal: Monitor_Helmsman
. . . . . [select: Observe_Turn_Progress_On_Gyrocompass
. . . . . Observe_Rudder_Angle_Indicator]
. . . goal: Make_Necessary_Corrections
. . . . [select goal: Turn_Ship
. . . . goal: Change_Speed_Of_Ship]
. . . goal: Receive_Steady_On_Course_Report
. . . . Listen_For_Steady_On_Course_Report
. . . . [select goal: Acknowledge_Report ...if received
. . . . goal: Request_Status_Of_Order_Execution] ...if not received

. . . goal: Get_Range_To_Replenishment_Ship
. . . . [select: Get_Range_From_Stadimeter
. . . . Call_For_Radar_Range]
. . . . goal: Determine_Range_Closing/Opening_Rate ...relative speed
. . . . . [select: Call_For_Current_Speed
. . . . . Observe_Speed_Indicator
. . . . . Estimate_Closing_Rate]
. . . goal: Shoot_Bearing_To_Replenishment_Ship
. . . . [select: Use_Alidade_On_Bridge_Wing
. . . . Call_For_Radar_Bearing] ...at night/low visibility
. . . goal: Determine_If_Lateral_Separation_Closing/Opening/Maintaining
. . . . [select: Use_Radian_Rule_Method
. . . . Use_Table_Of_Radian_Rule_Values_Method
. . . . Observe_Distance_Between_Wakes
. . . . Use_Seaman's_Eye_Method ...requires experience
. . . . Use_Combination_Of_The_Above]
. . . goal: Determine_If_Lateral_Separation_Too_Close/Far
. . . . [select: Use_Radian_Rule_Method
. . . . Use_Table_Of_Radian_Rule_Values_Method
. . . . Observe_Distance_Between_Wakes
. . . . Use_Seaman's_Eye_Method ...requires experience
. . . . Use_Combination_Of_The_Above]
. . . . goal: Make_Necessary_Corrections
. . . . . [select goal: Turn_Ship
. . . . goal: Change_Speed_Of_Ship]
. . . goal: Determine_If_Lateral_Separation_Is_Safe_To_Go_Alongside
. . . . Visually_Estimate_Lateral_Separation
. . . . goal: Make_Necessary_Corrections ...if not safe
. . . . . [select goal: Turn_Ship
. . . . . goal: Change_Speed_Of_Ship]
. . . goal: Monitor_Bow_As_It_Approaches_Replenishment_Ship's_Stern
. . . . Watch_For_Pressure_To_Push_Bow_Away_From_Stern

. goal: Complete_Alongside_Phase
. . goal: Determine_When_Bow_Crosses_Stern
. . . Visually_Estimate
. . goal: Watch_For_Bow_To_Be_Pushed_Away_From_Replenishment_Ship
. : . Observe_Bow_Motion ...high pressure area between bow and stern
. . goal: Monitor_Venturi_Effect_Alongside_Replenishment_Ship ...< 80 feet
. . . goal: Monitor_Lateral_Separation_Distance
. . . . [select: Observe_Wake_Action_Between_Ships
. . . . Visually_Estimate_Opening/Closing_Trend

. . . . Visually_Estimate_Lateral_Separation]
. . . . goal: Make_Necessary_Corrections ...if too far or close
. . . . . [select goal: Turn_Ship
. . . . . goal: Change_Speed_Of_Ship]
. . goal: Determine_Lateral_Separation ...>90 feet
. . . [select: Observe_Wake_Action_Between_Ships
. . . Visually_Estimate_Lateral_Separation_Distance]
. . . goal: Make_Necessary_Correction ...if too far or close
. . . . [select goal: Turn_Ship
. . . . goal: Change_Speed_Of_Ship]
. . goal: Determine_Range_To_Station_Closing_Rate
. . . goal: Determine_Range_To_Station
. . . . [select: Visually_Estimate_Distance
. . . . Observe_Rate_Which_Features_On_Replenishment_Ship_Pass]
. . . goal: Make_Necessary_Correction ...if too fast or slow
. . . . [select goal: Turn_Ship
. . . . goal: Change_Speed_Of_Ship]
. . goal: Determine_When_To_Match_Speeds
. . . Compare_Speed_Between_Ships_Estimate_When_To_Match_Speed
. . . . goal: Change_Speed_Of_Ship
. . goal: Maneuver_Close_To_Station_Alongside
. . . goal: Monitor_Ships_Heading_On_Gyrocompass ...repeats frequently
. . . . Observe_Bridge_Wing_Gyrocompass
. . . goal: Monitor_Lateral_Separation
. . . . [select: Observe_Wake_Between_Ships
. . . . Visually_Estimate_Opening /Closing_Trend]
. . . goal: Monitor_Fore_And_Aft_Motion
. . . . [select: Use_Replenishment_Ship's_Riggings_As_Range
. . . . Use_Replenishment_Ship's_Bulkhead_As_Range]
. . . goal: Make_ Necessary_Correction ...to move towards station
. . . . [select goal: Turn_Ship
. . . . goal: Change_Speed_Of_Ship]
. . goal: Get_Phone_And_Distance_Line_Across ...when near station
. . . Give_Order_To_Send_Phone_And_Distance_Line_Across
. . goal: Maintain_Station_Alongside ...loop until All Lines Clear
. . . goal: Monitor_Lateral_Separation
. . . . [select: Observe_Flags_On_Phone_And_Distance_Line_Open/Close
. . . . Visually_Estimate_Opening/Closing_Trend
. . . . Observe_Chemical_Lights_On_Phone_And_Distance_Line]
. . . goal: Monitor_Fore_And_Aft_Motion
. . . . [select: Use_Replenishment_Ship's_Riggings_As_Range
. . . . Use_Replenishment_Ship's_Bulkheads_As_Range

. . . . Observe_Angle_Of_Phone_And_Distance_Line]
. . . goal: Make_Necessary_Correction ...to stay on station
. . . . [select goal: Turn_Ship
. . . . goal: Change_Speed_Of_Ship]
. . . goal: Inform_Helmsman_Before_Lines_Are_Tensioned
. . . . Receive_Report_That_Lines_Are_Being_Tensioned
. . . . . goal: Inform_Helmsman_To_That_Lines_Are_Being_Tensioned
. . . . . [select goal: Receive_Repeat-back ...if received
. . . . . goal: Repeat_Order] ...if not received

. goal: Complete_Breakaway_Phase
. . goal: Maintain_Station_Alongside ...same loop as above
. . . goal: Monitor_Lateral_Separation
. . . . [select: Observe_Wake_Between_Ships
. . . . Visually_Estimate_Opening/Closing_Trend]
. . . goal: Monitor_Fore_And_Aft_Motion
. . . . [select: Use_Replenishment_Ship's_Riggings_As_Range
. . . . Use_Replenishment_Ship's_Bulkhead_As_Range]
. . . goal: Make_Necessary_Correction ...to move towards station
. . . . [select goal: Turn_Ship
. . . . goal: Change_Speed_Of_Ship]
. . . goal: Inform_Helmsman_Before_Lines_Are_De-tensioned
. . . . Receive_Report_That_Lines_Are_Being_De-tensioned
. . . . . goal: Inform_Helmsman_To_That_Lines_Are_Being_De-tensioned
. . . . . [select goal: Receive_ Repeat-back ...if received
. . . . . goal: Repeat_Order] ...if not received
. . goal: Determine_All_Lines_Clear
. . . [select: Visually_Verify_All_Lines_Clear
. . . Receive_Report_All_Lines_Clear]
. . goal: Receive_Breakaway_Order_From_CO
. . . Receive_Verbal_Order_From_CO
. . . goal: Acknowledge_Receiving_Order
. . . . Verbally_Repeat_Order_Received
. . goal: Breakaway ...start breakaway
. . . goal: Change_Speed_Of_Ship ...increase speed to pull away
. . . goal: Turn_Ship ...done in small increments until stern is clear
. . . goal: Monitor_Ship's_Turn ...until stern clear
. . . . Observe_Ship's_Stern_Does_Not_Move_Towards_Replenishment_Ship
. . . goal: Make_Necessary_Correction
. . . . [select goal: Turn_Ship ...see repeated methods
. . . . goal: Change_Speed_Of_Ship] ...see repeated methods
. . . goal: Determine_Stern_Is_Clear

. . . . Observe_Stern_Clear_Of_Replenishment_Ship's_Bow
. . goal: Go_To_Next_Station_Or_Duties_Assigned

B. TASK ANALYSIS OF AN OFFICER OF THE DECK DURING UNREP

1. Unit Task Level Analysis

goal: Execute_UNREP
. goal: Complete_Brief_Phase
. goal: Complete_Approach_Phase
. goal: Complete_Alongside_Phase
. goal: Complete_Breakaway_Phase

2. Functional Level Analysis

goal: Execute_UNREP
. goal: Complete_Brief_Phase
. . goal: Know_UNREP_Plan

. goal: Complete_Approach_Phase
. . goal: Know_UNREP_Plan
. . goal: Supervise_Bridge_Watch_Team
. . goal: Maintain_Communications
. . goal: Ensure_Safety_Of_Own_Ship
. . goal: Maintain_Awareness_Of_Third_Party_Ships
. . goal: Ensure_Own_Ship_Ready_To_Go_Alongside
. . goal: Ensure_Conning_Officer_Maintains_Station
. . goal: Supervise_Conning_Officer_During_Approach

. goal: Complete_Alongside_Phase
. . goal: Supervise_Conning_Officer_While_Alongside
. . goal: Determine_When_Bow_Crosses_Stern
. . goal: Watch_For_Bow_To_Be_Pushed_Away_From_Replenishment_Ship
. . goal: Monitor_Venturi_Effect_Alongside_Replenishment_Ship
. . goal: Determine_Lateral_Separation
. . goal: Determine_Range_To_Station_Closing_Rate
. . goal: Determine_When_To_Match_Speed
. . goal: Maneuver_Close_To_Station_Alongside
. . goal: Get_Phone_And_Distance_Line_Across
. . goal: Maintain_Station_Alongside ...loop until UNREP complete
. . goal: Supervise_Bridge_Watch_Team
. . goal: Maintain_Awareness_Of_Third_Party_Shipping

. . goal: Maintain_Communications

. goal: Complete_Breakaway_Phase
. . goal: Supervise_Conning_Office _While_Alongside
. . goal: Supervise_Bridge_Watch_Team
. . goal: Maintain_Awarness_Of_Third_Party_Shipping
. . goal: Know_Where_To_Go_Next
. . goal: Maintain_Communications

3. Detailed Level Analysis

goal: Execute_UNREP
. goal: Complete_Brief_Phase
. . goal: Know_UNREP_Plan
. . . [select: Go_To_OPS_Brief
. . . Go_To_CIC_Before_Watch
. . . Receive_UNREP_Brief_on_Bridge
. . . Talk_To_Operations_Officer_About_Changes
. . . Talk_To_CO_About_Plan]
. . . goal: Know_Plant_Configuration
. . . . [select: Go_To_OPS_Brief
. . . . Go_To_CCS_Before_Watch
. . . . Receive_UNREP_Brief_on_Bridge
. . . . Talk_To_Chief_Engineer_About_Plant_Status]

. goal: Complete_Approach_Phase
. . goal: Know_UNREP_Plan
. . . [select: Receive_UNREP_Brief_On_Bridge
. . . Talk_To_Operations_Officer_About_Changes
. . . Talk_To_CO_About_Plan]
. . . goal: Know_Plant_Configuration
. . . . [select: Call_CCS_From_Bridge
. . . . Ask_Lee_Helm_To_Get_Configuration_From_CCS
. . . . Talk_To_Chief_Engineer_About_Plant_Status]
. . . goal: Determine_Side_To_Approach_On
. . . . [select: Observe_ROMEO_Flag_On_Replenishment_Ship
. . . . Radio_Communication_With_Replenishment_Ship]
. . goal: Supervise_Bridge_Watch_Team
. . . goal: Ensure_Bridge_Manned_Ready ...before starting approach
. . . . Observe_Each_Station_Manned
. . . . . goal: Correct_Discrepancies ...if not manned
. . . . . Contact_Responsible_Department

. . . goal: Ensure_All_Communications_Equipment_Operational
. . . . Order_All_Watch_Standers_To_Do_Phone_Check
. . . . . goal: Correct_Discrepancies ...if not operational
. . . . . Contact_Responsible_Department
. . . goal: Ensure_Signalman_Has_Correct_Flags_Displayed
. . . . Observe_Flags_From_Bridge_Wing
. . . . . goal: Correct_Discrepancies ...if not correct
. . . . . Contact_Signalman
. . . goal: Ensure_Quartermaster_Has_Correct_Lights_Displayed
. . . . Observe_Masthead_Lights_From_Bridge_Wing
. . . . . goal: Correct_Discrepancies ...if not correct
. . . . . Contact_Quartermaster
. . . goal: Ensure_All_Bridge_Equipment_Setup_And_Operational
. . . . Check_Radar_Display
. . . . Check_Radios
. . . . Check_Miscellaneous_Equipment
. . . . . goal: Correct_Discrepancies ...if not operational
. . . . . Contact_Problem
. . . goal: Ensure_Bridge_Watch_Standers_Remain_Alert
. . . . Monitor_Behavior_Of_Watch_Standers
. . . . Control_Noise_Level_On_Bridge
. . . . . goal: Correct_Discrepancies ...if not alert
. . . . . Contact_Problem
. . goal: Maintain_Communications ...with CO, Conn, Helm and Lee helm
. . . [select goal: Communicate_With_Watch_Team
. . . . . [select: Yell_Through_Hatch
. . . . . Visual_Expression
. . . . . Verbal_Communications]
. . . . goal: Communicate_With_Other_Ships
. . . . . [select: Use_Bridge_To_Bridge_Radio
. . . . . Use_Secure_Radio
. . . . . Use_Flag_Signals
. . . . . Use_Flashing_Light_Signals]
. . . Verify_Message_Received]
. . goal: Ensure_Own_Ship_Ready_To_Go_Alongside
. . . Monitor_UNREP_Checklist
. . . goal: Ensure_All_Personnel_On_Station
. . . . Receive_Manned_Ready_Reports_From_UNREP_Stations
. . . . Receive_Manned_Ready_Reports_From_All_Department_Heads
. . . . goal: Contact_Department_Head_Of_Delinquent_Department
. . . . . Call_Department_Head
. . . goal: Set_Restricted_Maneuvering

. . . . goal: Get_Permission_To_Set_Restricted_Maneuvering_From_CO
. . . . goal: Pass_The_Word_That_Restricted_Maneuvering_Is_Set
. . . . . Announce_That_Restricted_Maneuvering_Is_Set
. . . goal: Inform_CO_Ship_Is_Manned_Ready_To_Go_Alongside
. . . . Make_Verbal_Report_To_CO
. . . goal: Raise_ROMEO_On_The_Side_To_Go_Alongside
. . . . Order_Signalman_To_Close-up_ROMEO
. . goal: Maintain_Awareness_Of_Third _Party_Ships ...done frequently
. . . [select: Visually_Scan_Horizon
. . . Observe_Radar_Display
. . . Communicate_With_Ship's_Combat_Information_Center
. . . Receive_Contact_Reports]
. . goal: Ensure_Safety_Of_Own_Ship
. . . Monitor_Third_Party_Shipping
. . . Make_Contact_Reports_To_CO
. . . Observe_Everything_In_Sight_And_Sound
. . goal: Ensure_Conning_Officer_Maintains_Station
. . . goal: Get_Bearing_And_Range_To_Replenishment_Ship
. . . . [select goal: Get_Bearing_To_Replenishment_Ship
. . . . . [select: Request_Bearing_From_Conning_Officer
. . . . . Use_Alidade_On_Bridge_Wing
. . . . . Replenishment_Ship's_Masts_Lineup
. . . . . Observe_Radar_Display
. . . . . Masthead_Lights_Of_Replenishment_Ship_Lineup
. . . . . Own_Ship_In_Wake_Of_UNREP_Ship]
. . . . goal: Get_Range_To_Replenishment_Ship
. . . . . [select: Request_Range_From_Conning_Officer
. . . . . Get_Range_From_Stadimeter
. . . . . Call_For_Radar_Range
. . . . . Visual_Estimate]
. . . Verify_On_Station]
. . . goal: Determine_If_Conning_Officer_Is_Conning_Safely
. . . . Compare_Current_Range_&_Bearing_To_Ordered_Range_&_Bearing
. . . . goal: Correct_Conning_Officer_As_Necessary
. . . . . [select goal: Coach_Conning_Officer
. . . . . . Make_Helpful_Course_Speed_Recommendations
. . . . . goal: Order_Conning_Officer_To_Correct_Problem
. . . . . . Give_Conning_Officer_Engine_Orders
. . . . . . Give_Conning_Officer_Rudder_Orders]
. . goal: Supervise_Conning_Officer_During_Approach ...CO does this
. . . goal: Observe_ROMEO_Close-up_On_Replenishment_Ship
. . . . [select: Observe_ROMEO_On_The_Side_Own_Ship_Will_Approach

. . . . Observe_Flashing_Light_Signal ...at night/low visibility
. . . . Receive_Radio_Transmission] ...at night/low visibility
. . . goal: Receive_Approach_Order_From_CO
. . . . [select: Receive_Verbal_Order_From_CO_To_Commence_Approach
. . . . Receive_Verbal_Order_Via_XO_To_Commence_Approach]
. . . . goal: Acknowledge_Receiving_Order
. . . . . Verbally_Repeat_Order_Received
. . . goal: Order_Conning_Officer_To_Commence_Approach
. . . . Verbally_Order_Conning_Officer
. . . goal: Monitor_Ship's_Turn ...may use multiple methods
. . . . [select: Observe_Rudder_Angle_Indicator
. . . . Observe_Feeling_Ship_Heel
. . . . Observe_Wake_Of_Own_Ship
. . . . Observe_Horizon
. . . . Observe_Gyrocompass_Heading_Change
. . . . Observe_Feeling_That_Ship_ Is_Turning
. . . . Observe_Rate_Of_Turn_Increase/Decrease]
. . . . goal: Monitor_Helm
. . . . . Observe_Turn_Progress_On_Gyrocompass
. . . . . Observe_Rudder_ Angle_Indicator
. . . goal: Monitor_Conning_Officer_During_Maneuver
. . . . goal: Correct_Conning_Officer_As_Necessary
. . . goal: Determine_Range_To_Replenishment_Ship
. . . . [select: Get_Range_From_Stadimeter
. . . . Call_For_Radar_Range]
. . . goal: Determine_Range_Closing/Opening_Rate
. . . . [select: Call_For_Current_Speed
. . . . Observe_Speed_Indicator
. . . . Estimate_Closing_Rate]
. . . goal: Determine_Lateral_Separation_Closing/Opening
. . . . goal: Shoot_Bearing_To_Replenishment_Ship
. . . . . [select: Use_Alidade_On_Bridge_Wing
. . . . . Call_For_Radar_Bearing] ...at night/low vis
. . . . goal: Determine_If_Lateral_Separation_Too_Close/Far
. . . . . [select: Use_Radian_Rule_Method
. . . . . Use_Table_Of_Radian_Rule_Values_Method
. . . . . Observe_Distance_Between_Wakes
. . . . . Use_Seaman's_Eye_Method ...requires experience
. . . . . Use_Combination_Of_The_Above]
. . . goal: Monitor_Conning_Officer_During_Maneuver
. . . . goal: Correct_Conning_Officer_As_Necessary
. . . goal: Monitor_Bow_As_It_Approaches_Replenishment_Ship's_Stern

. . . . Watch_For_Pressure_To_Push_Bow_Away_From_Stern
. . . goal: Determine_If_Lateral_Separation_Is_Safe_To_Go_Alongside
. . . . Visually_Estimate_Lateral_Separation
. . . goal: Monitor_Conning_Officer_During_Maneuver
. . . . Determine_If_Order_From_Conning_Officer_Correct_For_Situation
. . . . goal: Correct_Conning_Officer_As_Necessary
. . . . . [select goal: Coach_Conning_Officer
. . . . . . Make_Helpful_Course_Speed_Recommendations
. . . . . goal: Order_Conning_Officer_To_Correct_Problem
. . . . . . Give_Conning_Officer_Engine_Orders
. . . . . . Give_Conning_Officer_Rudder_Orders]

. goal: Complete_Alongside_Phase
. . goal: Supervise_Conning_Officer_While_Alongside ...CO does this
. . . goal: Monitor_Conning_Officer_During_Maneuver
. . . . Determine_If_Order_From_Conning_Officer_Correct_For_Situation
. . . . goal: Correct_Conning_Officer_As_Necessary
. . . . . [select goal: Coach_Conning_Officer
. . . . . . Make_Helpful_Course_Speed_Recommendations
. . . . . goal: Order_Conning_Officer_To_Correct_Problem
. . . . . . Give_Conning_Officer_Engine_Orders
. . . . . . Give_Conning_Officer_Rudder_Orders]
. . goal: Supervise_Bridge_Watch_Team
. . . goal: Ensure_All_Personnel_Are_Alert
. . . . Observe_Bridge_Watch_Standers
. . . goal: Ensure_All_Equipment_Failures_Are_Immediately_Corrected
. . . . Immediately_Contact_Responsible_Department
. . . goal: Ensure_Quartermaster_Maintains_Correct_Track
. . . . [select: Observe_Ship's_Track_On_Chart
. . . . Discuss_Ship's_Track_With_Quartermaster]
. . . goal: Maintain_Quiet_Bridge
. . . . Monitor_Conversation_And_Noise_Level_On_Bridge
. . goal: Determine_When_Bow_Crosses_Stern
. . . Visually_Estimate
. . goal: Watch_For_Bow_To_Be_Pushed_Away_From_Replenishment_Ship
. . . Observe_Bow_Motion
. . goal: Monitor_Venturi_Effect_Alongside_Replenishment_Ship ...< 80 feet
. . . Observe_Wake_Action_Between_Ships
. . . goal: Monitor_Lateral_Separation_Distance
. . . . Visually_Estimate_Opening/Closing_Trend ...depth perception
. . . . Visually_Estimate_Lateral_Separation ...depth perception
. . . goal: Monitor_Conning_Officer_During_Maneuver

. . . . goal: Correct_Conning_Officer_As_Necessary
. . goal: Determine_Lateral_Separation ...>80 feet
. . . [select: Observe_Wake_Action_Between_Ships
. . . Visually_Estimate_Lateral_Separation_Distance]
. . . goal: Monitor_Conning_Officer_During_Maneuver
. . . . goal: Correct_Conning_Officer_As_Necessary
. . goal: Determine_Range_To_Station_Closing_Rate
. . . goal: Determine_Range_To_Station
. . . . [select: Visually_Estimate_Distance
. . . . Observe_Rate_At_Which_Items_On_Replenishment_Ship_Pass]
. . . goal: Monitor_Conning_Officer_During_Maneuver
. . . . goal: Correct_Conning_Officer_As_Necessary
. . goal: Determine_When_To_Match_Speed
. . . Compare_Relative_Speed_Of_Ships_Estimate_When_To_Match_Speed
. . . . goal: Change_Speed_Of_Ship
. . goal: Maneuver_Close_To_Station_Alongside
. . . goal: Monitor_Ships_Heading_On_Gyrocompass
. . . . Observe_Bridge_Wing_Gyrocompass
. . . goal: Monitor_Lateral_Separation
. . . . Observe_Wake_Between_Ships
. . . . Visually_Estimate_Opening/Closing_Trend
. . . goal: Monitor_Fore_And_Aft_Motion
. . . . [select: Use_Replenishment_Ship's_Riggings_As_Range
. . . . Use_Replenishment_Ship's_Bulkhead_As_Range]
. . . goal: Monitor_Conning_Officer_During_Maneuver
. . . . goal: Correct_Conning_Officer_As_Necessary
. . goal: Get_Phone_And_Distance_Line_Across ...when on station
. . . Give_Order_To_Send_Phone_And_Distance_Line_Across
. . goal: Maintain_Station_Alongside ...loop until UNREP complete
. . . goal: Monitor_Lateral_Separation
. . . . [select: Observe_Flags_On_Phone_And_Distance_Line
. . . . Visually_Estimate_Opening/Closing_Trend
. . . . Observe_Chemical_Lights_On_Phone_And_Distance_Line]
. . . goal: Monitor_Fore_And_Aft_Motion
. . . . [select: Use_Replenishment_Ship's_Riggings_As_Range
. . . . Use_Replenishment_Ship's_Bulkheads_As_Range
. . . . Observe_Angle_Of_Phone_And_Distance_Line]
. . . goal: Monitor_Conning_Officer_During_Maneuver
. . . . goal: Correct_Conning_Officer_As_Necessary
. . . goal: Determine_Where_Own_Ship_Will_Go_After_UNREP
. . . . Discuss_Plans_With_Operations_Officer
. . . . Discuss_Plans_With_Combat_Information_Center_Watch_Officer

. . . . Discuss_Plans_With_CO
. . . goal: Monitor_Progress_Of_Stores_And_Fuel_Transfer
. . . . Receive_Progress_Reports_Form_UNREP_Stations
. . . . goal: Report_Progress_To_CO
. . . . . Make_Verbal_Report_To_CO

. goal: Complete_Breakaway_Phase
. . goal: Maintain_Station_Alongside
. . goal: Determine_All_Lines_Clear
. . . [select: Visually_Verify_All_Lines_Clear
. . . Receive_Report_All_Lines_Clear]
. . goal: Receive_Breakaway_Order_From_CO
. . . Receive_Verbal_Order_From_CO
. . . goal: Acknowledge_Receiving_Order
. . . . Verbally_Repeat_Order_Received
. . goal: Breakaway
. . . goal: Ensure_Conning_Officer_Commences_Breakaway_Maneuver
. . . . Observe_Conning_Officers_Actions
. . . goal: Monitor_Turn
. . . . Observe_Ship's_Stern_Doesn't_Move_Towards_Replenishment_ Ship
. . . goal: Monitor_Conning_Officer_During_Maneuver
. . . . Determine_If_Order_From_Conning_Officer_Correct_For_Situation
. . . . goal: Correct_Conning_Officer_As_Necessary
. . . . . [select goal: Coach_Conning_Officer
. . . . . . Make_Helpful_Recommendations
. . . . . goal: Order_Conning_Officer_To_Correct_Problem
. . . . . Give_Conning_Officer_Engine_Orders
. . . . . Give_Conning_Officer_Rudder_Orders]
. . . goal: Determine_Stern_Is_Clear
. . . . Observe_Stern_Clear_Of_Replenishment_Ship's_Bow
. . goal: Go_To_Next_Station_Or_Duties_Assigned

C. TASK ANALYSIS OF A HELMSMAN DURING UNREP

1. Unit Task Level Analysis

goal: Execute_UNREP
. goal: Complete_Approach_Phase
. goal: Complete_Alongside_Phase
. goal: Complete_Breakaway_Phase

2. Functional Level Analysis

goal: Execute_UNREP
. goal: Complete_Approach_Phase
. . goal: Maintain_Ordered_Course
. . goal: Turn_Ship_As_Ordered

. goal: Complete_Alongside_Phase
. . goal: Maintain_Ordered_Course
. . goal: Turn_Ship_ As_Ordered

. goal: Complete_Breakaway_Phase
. . goal: Maintain_Ordered_Course
. . goal: Turn_Ship_As_Ordered

3. Detailed Level Analysis

goal: Execute_UNREP
. goal: Complete_Approach_Phase
. . goal: Maintain_Ordered_Course ...normal condition loop
. . . Observe_Changes_In_Gyrocompass_Heading
. . . goal: Steer_To_Maintain_Ordered_Course
. . . . Turn_Wheel_As_Required_To_Maintain_Course ...within limits
. . goal: Turn_Ship_As_Ordered
. . . goal: Receive_Order_From_Conning_Officer
. . . . Listen_For_Order
. . . . goal: Repeat_Order_Back_To_Conning_Officer
. . . . . goal: Receive_Acknowledgement
. . . goal: Turn_Wheel
. . . . Turn_Wheel_In_Ordered_Direction_The_Ordered_Amount
. . . . goal: Report _That_The_Wheel_Is_Over_To_The_Conning_Officer
. . . . . goal: Receive_Acknowledgement
. . . goal: Monitor_Turn
. . . . [select: Observe_Changes_In_Gyrocompass_Heading
. . . . Observe_Rate_Of_Ships_Turn
. . . . Observe_Rudder_Angle_Indicator
. . . . Observe_Feel_Of_Ship_Turn
. . . . Observe_Horizon]
. . . goal: Stop_Ships_Turn_On_Ordered_Course
. . . . Estimate_When_To_Reduce_Degree_Of_Rudder
. . . . goal: Reduce_Rudder_To_Slow_Swing_Of_Ship
. . . . . Turn_Wheel_As_Required
. . . . goal: Stop_The_Swing_Of_The_Ship

. . . . . Estimate_Degree_Of_Counter_Rudder_To_Stop_Swing_Of_Ship
. . . . . goal: Counter_Steer_To_Stop_Swing_Of_Ship
. . . . . Turn_Wheel_As_Required_In_Opposite_Direction_Of_Turn
. . . . goal: Steady_Ship_On_Ordered_Course
. . . . . Make_Small_Steering_Corrections_Until_Ship_Is_Steady_On_Course
. . . . goal: Report_Ship_Steady_On_Ordered_Course_To_Conning_Officer
. . . goal: Inform_Conning_Officer_Of_Steering_Problems
. . . . goal: Detect_Steering_System_Casualty
. . . . . [select: Observe_Steering_Alarms
. . . . Notice_No/ Slow_Response_To_Turn_Of_Wheel
. . . . Receive_Steering_Casualty_Message_From_Aft_Steering
. . . . Notice_Loss_Of_Gyrocompass]
. . . . goal: Detect_Steering_Problems_Related_To_Sea_Condition
. . . . . Notice_Need_To_Use_More_Rudder_Than_Normally_Required
. . . . . goal: Get_Permission_From_Conning_Officer_To_Use_More_Rudder
. . . goal: Maintain_Communications ...with Conning Officer
: . . . [select: Use_Amplified_Communications_System
. . . Use_Someone_To_Relay] ...if amp fail/not available
. . . . Verify_Communications_Received

D. TASK ANALYSIS OF A LEE HELMSMAN DURING UNREP

1. Unit Task Level Analysis

goal: Execute_UNREP
. goal: Complete_Approach_Phase
. goal: Complete_Alongside_Phase
. goal: Complete_Breakaway_Phase

2. Functional Level Analysis

goal: Execute_UNREP
. goal: Complete_Approach_Phase
. . goal: Maintain_Ordered_Speed
. . goal: Change_Speed_As_Ordered

. goal: Complete_Alongside_Phase
. . goal: Maintain_Ordered_Speed
. . goal: Change_Speed_As_Ordered

. goal: Complete_Breakaway_Phase
. . goal: Maintain_Ordered_Speed

. . goal: Change_Speed_As_Ordered

3. Detailed Level Analysis

goal: Execute_UNREP
. goal: Complete_Approach_Phase
. . goal: Maintain_Ordered_Speed ...normal condition loop
. . . [select: Observe_Throttle ...ensure it is not moved
. . . Observe_RPM_Indicator
. . . Observe_Pitch_Indicator
. . . Observe_Speed_Indicator]
. . goal: Change_Speed_As_Ordered
. . . goal: Receive_Engine_Order
. . . . Listen_For_Order_From_Conning_Officer
. . . . goal: Repeat_Order_Back_To_Conning_Officer
. . . goal: Change_Throttle_To_Ordered_Speed
. . . . [select: Change_Throttle_To_Match_RPM_Of_Ordered_Speed
. . . Change_Throttle_To_Match_Pitch_Of_Ordered_Speed]
. . . goal: Report_Pitch/RPM_Change_Complete_To_Conning_Officer
. . . goal: Inform_Conning_Officer_Of_Engineering_Problems
. . . . goal: Detect_Unusual_Changes_In_RPM
. . . . . Observe_RPM_Indicator
. . . . . Report_Problem_To_Conning_Officer
. . . . goal: Detect_Unusual_Changes_In_Pitch
. . . . . Observe_Pitch_Indicator
. . . . . Report_Problem_To_Conning_Officer
. . . . goal: Detect_No/Slow_Response_To_Throttle_Changes
. . . . . Report_Problem_To_Conning_Officer
. . . goal: Maintain_Communications ...with CCS, Aft Steering,
. . . . [select: Use_Amplified_Communications_System
. . . Use_Someone_To_Relay]
. . . . Verify_Order_Received

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